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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

FOURTH ANNUAL GENERAL MEETING,

HELD IN BIRMINGHAM, ON 23RD JANUARY, 1851.

J. E. McCONNELL, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
PRINTED AT M. BILLING'S STEAM PRESS OFFICES,
74, 75, & 76, NEWHALL STREET.

1851.

PROCEEDINGS.

THE FOURTH ANNUAL GENERAL MEETING of the Members was held in the House of the Institution, Newhall Street, Birmingham, on Wednesday, January 22, 1851; J. E. MCCONNELL, Esq., Vice-President, in the Chair.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The SECRETARY then read the following:—

REPORT OF THE COUNCIL,

AT THE FOURTH ANNUAL MEETING, 22ND JANUARY, 1851.

THE Council congratulate the Members on the satisfactory position of the Institution at the present Fourth Anniversary of its establishment, and on its continued and successful progress in efficiency and usefulness.

The number of Members for the last year is 202, of whom 16 are Honorary Members, and 3 Graduates; the class of Graduates has been specially formed to enable the young and rising members of the profession to obtain the advantages which the Institution is so well calculated to afford.

The Financial statement of the affairs of the Institution for the year ending 31st December, 1850, shows a Balance in the Treasurer's hands of £230 3*s*. 0*d*., after the payment of all accounts due to that date, and this Balance has been further increased to £265 3*s*. 0*d*. by the receipt since 31st December of some subscriptions due for the last year, 1850. The Finance Committee have examined and checked all the receipts and payments of the Institution for the year 1850, and have reported that the following Balance Sheet, rendered by the Treasurer, is correct.

(See Balance Sheet appended.)

The Offices of the Institution have been established in the present building, containing the accommodation for the Meeting Room and Library, and for the Secretary to be resident on the premises, and affording additional facilities for promoting the usefulness of the Institution, and its efficiency in accomplishing the objects for which it was established. The Council hope to receive from the Members and their friends contributions of Books and Drawings, for the formation of a Library of reference, and Models of Machinery, &c., to form a Museum of Mechanical Models, for the use of the Institution.

The Council have the pleasure of announcing that the following donations to the funds and the library of the Institution, have been received during the past year.

Donation of £100 from the President, Mr. Robert Stephenson.
Proof copy of Work on the Britannia and Conway Tubular Bridges, from Mr. Robert Stephenson.
Paul R. Hodge on the Principles and Practical Application of the Expansive Steam Engine, from the Author.
W. Lee's Tables of the Strength and Deflection of Timber, from the Author.
F. Galton on the Telotype or Printing Electric Telegraph, from the Author.
W. Spence on Patentable Invention, from the Author.
The Mechanic's Magazine, from the Editor.
The Practical Mechanic's Journal, from the Editor.
The Civil Engineer and Architect's Journal, from the Editor.
The Artizan, from the Editor.
The Engineer and Machinist, from the Editor.
The Mining Journal, from the Editor.
The London Journal of Arts, from the Editor.
The Patent Journal, from the Editor.
Proof Engraving of the Building for the Exhibition of 1851, from Messrs. Fox, Henderson, and Co.

Amongst the communications and discussions at the Meetings of the Institution, during the last year, the Council have

the pleasure of referring to the following as valuable and interesting, leading to improvement and economy, and to the advancement of the knowledge of the form and strength of materials.

The Condensation of Steam in the Engines of the South Staffordshire Iron District, and the Improvements to be effected in them.

A new construction of Blowing Engine for Blast Furnaces, working at high velocities.

A new construction of Reciprocating Steam Engine.

The Form and the Deterioration of Railway Axles.

The Form and Construction of Railway Carriage and Waggon Springs.

The Improvement of the Construction of Railway Carrying Stock.

The Inventions and Life of the late William Murdock, of Soho.

The Council wish to draw the particular attention of the Members to the importance of giving all the assistance in their power to advance the objects and increase the utility of the Institution, by the communication of Papers with Drawings and Models, descriptive of new inventions or improvements that have been made by them, or have come under their observation, and the results of experiments, and of the practical working of old or new Machinery, Engines, &c., with Indicator Cards from Steam Engines, so as to render the Institution a general place for reference on Mechanical subjects. A list of proposed Subjects for Papers is appended, and the Council invite communications from all the Members and their friends on these and any other Engineering subjects that will be useful and interesting to the Institution, and they hope to receive a further increase of the papers, so as to add to the number of the meetings; they trust that no members will withhold their communications on account of the want of opportunity to make them so complete and lengthened as they may desire, as it is one of the first objects of the Institution to collect and record facts relating to the professional experience of the members, and to procure early and authentic information

respecting new mechanical inventions and improvements, for the mutual information and advantage of the members.

In the ensuing year an excellent opportunity will be afforded by the concourse of visitors from all foreign countries at the Great Exhibition in London, to open communication with foreign Engineering Societies for mutual advantage and the interchange of Transactions; and in furtherance of this object it would be advisable to obtain corresponding Members of the Institution in various countries, and the Council also recommend this opportunity to be taken for holding a Meeting of the Institution in London.

The Officers of the Institution and Five of the Members of the Council go out of office this day, according to the Rules, and the ballot will be taken at the present meeting for the election of the Officers, &c., for the ensuing year.

The CHAIRMAN observed, that all the members must feel great satisfaction in the rise and progress of the Institution of Mechanical Engineers; he congratulated them on the proceedings of the last year, and the excellent papers that had been brought before them, comprising questions of great practical value, and on the favourable prospect of papers for the ensuing year, and he thought there was no doubt that the important occasion of the great Industrial Meeting in London, when Engineers from every country in the world would meet together, would also stimulate the Members of this Institution, in producing for that period some papers of importance and value.

He believed that a great deal of good might be done by establishing a connexion with foreign Engineering Societies; he had the pleasure recently of meeting the President of the French Institution of Engineers, and of finding that shortly after their last meeting he was in possession of their report, and he spoke in high terms of the usefulness of the Institution, and the valuable practical character of the papers. He thought it would be well to establish a system of intercommunication with Foreign Engineering and Mechanical Societies, thus leading to an interchange of

the ideas and practical suggestions thrown out by the respective bodies, and tending to the establishment of that friendly feeling which ought to exist between the members of the profession, in event of any of them visiting their respective countries, and certainly the present was an auspicious era for bringing about so desirable an object.

The introduction into the Institution of young and rising members of the profession, in the capacity of Graduates, he felt would be an important aid to the future success and prosperity of the Institution; by their introduction into the Institution they would become acquainted with the principles of the system on which it was conducted, they would take an increasing interest in it, and form a very useful addition. A young engineer entering an Institution like the present, listening to the discussion on the various subjects brought before them, might have his mind awakened by some remark, which, as frequently occurred, might lead him to some practical result of importance and advantage; and the more of that class of active, intelligent minds they could bring to bear in the Institution, the greater the practical results would be. He trusted that every head of an Establishment who had within his influence any young member of the profession, whom he thought would form a useful graduate, would use his efforts and influence to bring him amongst them: he should even be glad to see the number of these graduates equal with that of the Members of the Institution. In conclusion, he congratulated the Members upon the successful issue of their proceedings up to the present time, and he hoped that the Institution would go on increasing in usefulness and efficiency.

On the motion of Mr. Williams, seconded by Mr. Buckle, the Report was received and adopted.

Mr. GIBBONS moved a vote of thanks to the Council and Officers of the Institution, for their services during the past year. The motion was seconded by Mr. Dockray, and passed.

The CHAIRMAN then announced, that the ballot lists had been opened by the Committee appointed for the purpose, and the following Officers and Members of Council elected for the ensuing year.

President:
ROBERT STEPHENSON, M.P., London.

Vice-Presidents:

CHARLES BEYER, Manchester.
J. E. MCCONNELL, Wolverton.
JOHN PENN, London.

Council:

E. A. COWPER, Birmingham.
EDWARD HUMPHRYS, Woolwich.
EDWARD JONES, Bridgewater.
WILLIAM A. MATTHEWS, Sheffield.
ARCHIBALD SLATE, Dudley.

(In addition to the ten Members of Council who continue in office from the last year.)

Treasurer:
CHARLES GEACH, Birmingham.

Secretary:
WILLIAM P. MARSHALL, Birmingham.

The CHAIRMAN announced that the following new Members were also elected.

Members:

S. HOLDEN BLACKWELL, Dudley.
GEORGE DOWNING, Smethwick.
JOHN RHODES, Hull.
J.T. WOODHOUSE, Ashby-de-la-Zouch.

The CHAIRMAN said he was happy to announce that the subscriptions towards erecting the National Memorial to the late George Stephenson amounted already to £2320, and the Committee were very sanguine that something like double the amount would be realized.

Mr. BENJAMIN GIBBONS observed, in reply to a remark made at the last Meeting, with reference to the invention of the Pneumatic Lift, that he had described at a former Meeting, (see Proceedings, July, 1849,) that Mr. Middleton was under a mistake in attributing it to the late Mr. Murdock, of Soho. At that time he (Mr. Gibbons) had an intention of altering his furnaces to increase their height, but met with a serious obstacle in the confined situation of the Works, the furnaces standing close to the canal towing path, which prevented the use of the usual inclined plane for raising the materials to the top of the furnaces. He then thought that the blast, with which the furnaces was blown,

might be made use of for the purpose of the lift, and he asked the opinion of Mr. Murdock on the subject, with whom he was on intimate terms, and who promised to give it his consideration. A few days afterwards, he was standing near the Dry Regulator, when he observed (the blast being suddenly taken off the furnace), that the piston of the regulator rose beyond its usual working limits, till it was raised to the level which opened the escape valve. It then immediately struck him that, if the cylinder were long enough the piston would have continued to rise to the height required, and if a piston loaded with 7 or 8 tons were thus raised, why might not 7 or 8 tons of iron-stone be raised by a similar agency? It was obvious, that the same thing would apply to the Water Regulator, which being a cylinder open at the bottom, inverted in water, and the blast admitted beneath it, had the same tendency to rise, unless held down by bolts. He considered the latter plan cheaper and more applicable under the circumstances; having a rise of 16 feet, he had only to make his water regulator long enough, and it would take up any weight proportioned to the area of the cylinder. Some time after this plan was resolved upon, Mr. Murdock sent him, on his return from Cornwall, a plan for a wheel to be acted upon by the blast; it was a wheel immersed in water, with buckets like an over-shot water-wheel, and the weight might probably have been wound up by it; but he saw that the water regulator was the exact thing required, and therefore did not try Mr. Murdock's plan. He might mention, that when Mr. Murdock afterwards saw his application of the water regulator, he said, that had that idea occurred to him he would not have suggested the water-wheel, for, added he, "your plan is better than mine." The plan has answered completely the purposes for which it was intended. All who had the pleasure of Mr. Murdock's acquaintance, well knew with what readiness he laid open the stores of his mind to any one in whom he took an interest, and his ingenuity of mind, amenity of manner, and kindness of character had established for him a world-wide fame. Indeed, they had only to look around the room in which they were assembled, and if it were not for one of his brilliant discoveries (referring to the gas by which the room was lighted), they would find themselves very much in the dark.

Mr. Buckle remarked, in the absence of Mr. Middleton, that he had expressed to him his regret at any observation on the subject that he might have made under a mistake; what he claimed for Mr. Murdock was the perfection of the blast engine, whilst Mr. Gibbons had, it appeared, adapted the water regulator to the purpose of the lift. He also bore his testimony to the excellency of the plan adopted by Mr. Gibbons: he was of opinion it was a most excellent method of lift.

The following supplementary paper, by Mr. W. A. Adams, of Birmingham, was then read:—

ON THE IMPROVEMENT OF THE CONSTRUCTION OF RAILWAY CARRYING STOCK.

In the previous paper laid before the last meeting of the Institution the great increase was pointed out that has gradually been made in the dead weight of the carrying stock in the general practice of railways; that the First Class Carriages carrying 18 passengers have been increased in dead weight from 3¼ tons to 5 tons; and the Waggons carrying a maximum load of 5 tons have reached a dead weight of 4¾ tons; and that this great increase of dead weight occasioned an important addition to the cost of locomotive power for the nett load carried. If a Locomotive Engine is capable of conveying a train of 50 waggons, weighing 200 tons, and the load 200 tons (which proportion of dead weight to load will not be short of the truth, even without taking empties into account), a saving of *one ton* in the dead weight of each waggon will enable the engine to convey 50 tons additional of waggons and load, or equal to a saving of *one-eighth* in the cost of haulage.

In the important matter of inland through coal traffic, the waggon averaging 3¾ tons carries 5 tons of coal; but as the waggon has to return empty, for 5 tons of load conveyed one mile, 7½ *tons dead weight* of waggon has to be conveyed the same distance. In this instance the saving of *one ton* weight in the construction of the waggon would be equivalent to a total saving of nearly *one-sixth*, or 16 *per cent.* in the cost of haulage.

The great increase in dead weight has arisen from the increase

that has been continually making in the quantity and weight of material employed in the construction of railway carriages and waggons, as the remedy for the failure of their different parts; that remedy having generally been solely increase of weight of material, without alteration of material or construction.

In the common road vehicles, where the motive power was limited, the road imperfect and gradients bad, the cost of hauling power was of so great importance, that every pound of weight was carefully saved in the construction of the vehicles, by using only the best materials and construction to obtain the strength with the least weight; the durability being comparatively a secondary consideration. The Four-horse Coach, conveying 18 passengers, weighed only 1 ton, and the Van, conveying 6 tons of goods, weighed about 1¼ tons.

The great distinction between road and railway vehicles is, that railway vehicles have to sustain longitudinal strains in the direction of the buffing, as well as lateral and perpendicular blows. The reduction of the dead weight of railway vehicles is extremely desirable, while such reduction of weight is effected with due regard to efficiency and strength to resist the longitudinal strain in buffing, as well as the other strains to which they are subjected. The object is to produce such vehicles as shall be, all points considered, the most economical in first cost, in maintenance, and especially in traction: and at the same time it does not follow that reducing the dead weight, and improving the quality of the materials, will add materially, if any, to the cost.

The *Sole-Bar* is the most important part of the waggon underframe, as it resists the main force to which the waggon is subjected, namely, the longitudinal buffing, and also acts as a girder to carry the load upon the springs. The ordinary wood sole-bar averages from 10 to 12 inches deep, and 3½ to 5 inches thick. Although the principal strain is the end-way buffing, the vertical strength is required to be so much greater than the lateral strength, in consequence of the sole-bar being strutted horizontally by the internal framing.

The writer has endeavoured to discover the best form to attain the same strength in wrought-iron with the least material, and thereby ascertain whether the same strength can be attained with less weight than the ordinary wood sole-bar.

Fig. 1 (Plate 18) is a section of the ordinary English oak sole-bar, of the average dimensions, 11 inches deep and 4½ inches thick; the length is 13 feet, and the total weight by actual practice, 321 lbs.

The correct theoretical section for wrought-iron to answer the same purpose with the least material, would appear to be a box-girder as shown in Fig. 2. But this cannot be practically adopted, as it would be next to impossible to manufacture, and it is necessary that some practical form of rolled-iron be adopted, for economy and simplicity of construction.

The main force to be resisted is the end way buffing, and as the strongest form to resist end pressure with the least material would be a tube (as shown dotted in Fig. 3), that section which imitates a tube the nearest will be the correct form. The strength of the tube arises from the metal being distributed at the greatest distance from the centre, therefore in the section, Fig. 3, the metal has been principally distributed in three points AAA of the circumference of the circle which are connected by the thin sides of the iron.

Inasmuch as the vertical strength is required to be considerably greater than the lateral strength, this theoretical section, Fig. 3, requires altering to the proportion shown in Fig. 4.

The practical section proposed to be adopted on this principle is shown in Fig. 5, the height is 7 inches and the width 4 inches; the sides should be as thin as practicable, and the metal thrown into the extremities, the sides are therefore $\frac{5}{16}$ inch thick, and the extremities $\frac{7}{8}$ inch thick. The weight of this section 13 feet length, is 219 lbs., being nearly one-third less than the ordinary oak sole-bar, which weighs 321 lbs.

The following experiments have been tried by the writer to ascertain the requisite strength of iron to be employed for this purpose.

An English oak sole-bar, 10 feet long, and of the section, Fig. 1, of picked quality and straight grained, was subjected to end-way pressure in a hydraulic press, being supported only at the two ends.

15	tons, deflected it		$\frac{3}{8}$	inch at the centre.	
22½	ditto	ditto	½	ditto	ditto.
30	ditto	ditto	$\frac{5}{8}$	ditto	ditto.
35	ditto	ditto		when it broke.	

The breaking did not appear to be caused by deflection, but by the crushing and lateral separation of the fibres; the principal fracture being several feet in length and extending from side to side on the edgeway of the timber.

A wrought-iron bar, of the Great Western section, shown in Fig. 6, and the same length, 10 feet, was fixed in the press in the same manner.

15 tons, deflection none.
19 tons deflected it ¼ inch, without set.
22½ „ „ 4 inches, permanent set 2¾ in.

The deflection was entirely lateral, and in the direction of the arrow, or towards the side of the larger flange.

This bar is made of two pieces rivetted together, one 7 inches high and ½ inch thick, with a small flange on one side, and an angle iron, 3 inches wide, is rivetted to it on the opposite side.

To ascertain the comparative vertical strength, an English oak sole-bar of Fig. 5 section, was placed edgeways on two supports, 6 feet apart, and the force of the press applied in the centre.

10 tons deflected it ⅛ inch.
12 ditto ditto ⅝ ditto.
16 ditto ditto broke it.

The wrought-iron bar of Fig. 6 section, was tried in the same manner, with the force applied on the edge, and supported on the flange.

10 tons deflected it ¼ inch.
12 ditto ditto ⅝ ditto, permanent set ⅜ inch.

From the results of these experiments it appears that the iron bar, Fig. 6, is about as strong as the wood sole-bar, Fig. 1, to resist vertical force, but is somewhat deficient in strength to resist the endway buffing. In this section a loss of strength is caused by its being made in two pieces rivetted together; the deficiency is in lateral stiffness, which would be considerably increased if it were all one solid bar of iron. It appears from the following experiment that the deflection would be on the *opposite side* to the large flange, if the whole were solid.

A bar 7½ feet long of the section, Fig. 7, was subjected to endway pressure in the same manner as before; the depth was 6 inches, the width 3½ inches, and thickness ⅝ inch.

23 tons produced no permanent set.

26 tons produced a permanent set of 1¾ inch laterally, and
1¼ inch vertically,

the deflection being on the *opposite side* to the flange, as shown by the arrow.

Also a bar, 5½ feet long of the section, Fig. 8, was tried in the same manner by end pressure; the depth and width were both 3 inches, and the thickness ⅜ inch.

9 tons produced a permanent set of 1 inch, both laterally
and vertically the same,

the deflection being in the *opposite direction* to the flanges, and diagonally as shown by the arrow, from the depth and width being equal.

From these results it appears that the two edges of the bar became compressed by the pressure more than the rest of the section, and allowed the bar to bend outwards. These edges are consequently strengthened in the proposed section, Fig. 9, by increasing the thickness which will diminish the deflection, and enable the bar to resist a greater endway strain without permanent set.

The sectional area of Fig. 6, the bar first experimented upon is 6½ inches, that of Fig. 7 is 5½ inches and that of Fig. 5, the proposed section is 5 inches, but the latter is expected to be stronger than Fig. 6, on account of the greater power to resist deflection, from the edges being strengthened and the bar being made in one solid piece, and that it will prove amply sufficient for the requirements. An important circumstance in the comparison of strength between wrought-iron and wood is, that with iron the full experimental strength is obtained in practice, but in wood the strength obtained in practice is considerably less than that shown by experiment, on account of the defects to which timber is liable and the mortices and bolt holes cut into it.

The writer is about to have a quantity of iron rolled to the proposed Section, Fig. 5, for the purpose of constructing certain waggons, and hopes to be enabled previous to the next meeting to give the results of actual trial.

A very important advantage will be obtained by the use of Iron from its greater durability. English Oak, admitted to be the best material, cannot be procured in a thoroughly seasoned state in any large quantities, and is consequently, after it is made up, in a transition state for a term of years. The timber opens and shrinks, and the joints loosen, admitting wet and accelerating the decay.

Presuming that an efficient waggon frame be practicable from iron, it is difficult to place a limit upon the period of its duration, if well preserved from oxidation by paint or tar; and it may be expected to be still in an efficient condition at the time when wood requires renewal.

It should be noted that the English oak, weighing 72 lbs. per cubic foot, is in the unseasoned state in which it is generally used for waggons; and that as it seasons in work it lessens considerably in weight, but at the same time loses in strength.

The writer has not had the opportunity at present for carrying out his investigation into the application of iron to the construction of railway vehicles, further than the principal portions of the underframe, but proposes to continue the subject practically before the next meeting.

Mr. T. Thorneycroft observed, that he had witnessed some of the experiments that were described in Mr. Adams' paper, and could testify to the accuracy with which they were performed.

Mr Dockray suggested it would be difficult to roll a bar of iron of the proposed section, Fig. 5.

Mr. T. Thorneycroft thought it could be effected, but it would be accompanied by some difficulty.

Mr. Jones proposed it should be rolled with the ends flattened out a little, and that they should be closed in at the last time of passing through the rolls.

Mr. Slate remarked, that the author's deductions appeared to lead him to the conclusion that the hollow rectangular section, Fig. 2, was the best form, provided the iron could be rolled into that shape, but he diverged into the L form because it was the only practicable shape. He thought there would be no difficulty about rolling the section, Fig. 2, but there would be some difficulty about the other; if it were sufficient for the purpose of fixing the cross framing, it could be rolled out as easily as a tube, and with the aid of another mandril, might be flattened into any rectangular shape desired, which would probably be less expensive than rolling the L section.

Mr. SELBY apprehended no difficulty in making it in that manner as a tube; at all events he should be glad to make the trial. He could also prepare it by a process which would prevent the oxidation of the iron, providing it was not knocked about.

Mr. COWPER remarked, that the cost of rolling the proposed L section, Fig. 5, might not be more than £2 per ton extra upon bar iron.

Mr. ALLAN inquired how the Great Western plan was found to answer, for they had some hundred waggons running, made with the frame of the section, Fig. 6.

Mr. BARRANS suggested the adoption of the rectangular section, Fig. 2, with wood blocks filled in where required, and bolted through to give strength to the frame. He asked if it could not be rolled in two parts and rivetted together afterwards.

Mr. ADAMS replied, that would bring them to an increase in cost per ton, and the expense was an important matter to be taken into consideration. It was desirable to get a square side and bottom for attaching the spring shoes, with the cross bearers merely rivetted through, and he thought a mitre joint at the corners of the frame would be necessary, and that the proposed L section, Fig. 5, was the most convenient for all these purposes.

Mr. WRIGHT said, that in considering the increase in weight of Railway Carriages it must be borne in mind that the public had demanded increase of strength and room as essential to comfort and security, more especially in rapid travelling. He thought the comparison between the common road coach and the railway carriage would not hold, because not only did they go at a very limited speed, but they were provided by contractors, who for the sake of their horses, had the vehicles as light as possible; and it must be remembered there was no danger arising from collisions; there was no buffing, but only traction. The uniform requirement of the public had been for an increase of strength in the railway plant, and they had abundant proof that the original carriages with open frames had not been strong enough to bear concussion, for in collisions such carriages received all the damage, whilst the modern strong built carriages escaped uninjured. According to the views of the writer of the paper, in increasing the

weight of carriages, as a necessary consequence of increased size and strength, they had been going back instead of forward; but he was not of that opinion, on the contrary he thought they were decidedly improving in construction. He could not imagine that the iron sole bar proposed would be so strong as the wood, and he thought good seasoned oak timber would be found preferable for the purpose.

Mr. ADAMS observed, that the original carriages had not been found strong enough for the duties they had to perform, but he considered that in increasing their strength the dead weight had been too much increased from the want of scientific principles in the construction.

Mr. COWPER remarked, that the observations of the paper were directed to find out the best kind of frame, and to discover the mode of making a good frame as light as possible, consistent with strength and durability. He thought that the proposed section, Fig. 5, seemed to give a good result; and he could speak practically on the subject, because he had made a great number of experiments on the end thrust of L and T iron for iron roofs, and he had found that when the edges of the flange were thin, the iron was defective in strength to resist an endway thrust. The metal at a distance from the general centre of the section was most advantageously placed for strength, and in the section Fig. 5, the metal was distributed as far as possible from the centre, thereby securing the full advantages obtained by the depth.

Mr. SLATE conceived it a matter of the highest importance to diminish dead weight, and that great improvements had yet to be effected in that particular; certainly if they had now 5 tons of dead weight where they had formerly 3¼ tons, they had not much improved, for they had thereby increased the cost of traction one-half. He did not know of any instance where there was so large a proportion of dead weight in any kind of machinery as there was in railway rolling stock; and the dividends on railway property must be diminished by it. It was surprising that on a road possessing such perfection and advantages, they should have such an enormous proportion of dead weight; in an abstract sense it rendered the new railways less perfect than the old roads, where the proportion of dead weight was so much less.

Mr. H. WRIGHT thought it ought to be observed, that railway carriages had been much increased in their size, to suit the convenience and comfort of travellers. Originally they were 15 feet long, 6 feet 6 inches wide, and 4 feet 9 inches high; but now they were from 18 to 20 feet in length, 7 feet wide, and 5 feet 6 inches high. The increase in size was of course one element in the increase of weight.

Mr. CLIFT remarked, that the great increase in speed in the case of railway travelling must be considered, and the necessity for greater strength as a means of preventing accident. At the commencement of the railway system, accidents were frequent; and when they occurred they were of a very serious nature. This was attributed to the lightness of the carriages, and no doubt the question of increasing strength had been forced upon the carriage builders, by the demands of public safety, as well as the danger resulting to the rolling stock, when carriages came into collision. The coal waggons were indeed made as strong as possible, on the principle that if they came in collision with any others, they might from their superior strength, withstand the shock themselves, and crush the others.

Mr. WRIGHT observed, that the increase of weight had been forced upon them on the principle of public safety. Originally, in the case of the axle journals, they were $4\frac{1}{2}$ by $2\frac{3}{16}$ inches; but they had soon increased to 5 by $2\frac{5}{8}$ inches, and were now much larger; also, the wheels were originally 17 cwt., but now they weighed from 25 cwt. to 27 cwt. These had to do the same business; the number of passengers were not increased, but the vehicles to carry them were heavier. It would be found in the case of the old road coaches, that their utmost speed was twelve miles an hour, generally not more than nine miles, and yet accidents were perpetually occurring, and were far greater than at present on railways.

Mr. GIBBONS remarked, that the question under discussion, was the substitution of one material for another, of the same strength, not with less strength, but with an economy of weight.

Mr. SLATE thought it was important to consider, that the greater the weight, the greater would be the momentum, and

the greater the damage done by a collision. He saw no reason why the dead weight should not be reduced nearly one-half.

Mr. Henson was of opinion, that before long, the dead weight would be reduced one-third, while the weight carried was increased one-third: and that the cost would be also diminished. He was engaged in the consideration of the subject, and would be glad to bring the results before the Institution, at a future meeting.

The thanks of the meeting were voted to Mr. Adams, for his communication; and the following paper, by Mr. Parkinson, of London, was then read:—

ON A WATER METER.

There may be considered to be two descriptions of Water Meters, as is the case with Gas Meters; one in which the meter is turned by the pressure arising from the elevated source of the supply, and the other by the gravity or weight of the water; in other words, one working under pressure and the other not. Perhaps the first Water Meter ever constructed was similar to a steam engine with cylinder, piston, crank, &c., &c. This description of meter is worked by the pressure, and the water will rise beyond the meter to any elevation short of that by which it is moved, save the friction of the meter. The one moved by the weight or gravity of the water will not allow the water to rise above the point of discharge, it is therefore indispensible that this meter should be placed above the point where the highest supply is required; and if this should be in the highest room in a house, the meter must be placed a little above, and of course every room below will be easily supplied by the gravity of the water.

On each of these plans a variety of designs have been attempted; —on the high-pressure principle, besides the cylinder, various rotatory plans having been tried,—and on the plan of gravity various wheels with buckets, and vessels with floats, the rising and falling of which reversed the valves, or stop-cocks, for the inlet and outlet of the water.

The chief objections to the high-pressure principle are the difficulties of making the machines perfectly water-tight, easy to move and of cheap construction, to bear the varieties of pressure and

speed to which they may be subjected; another obstacle is the non-elasticity of the water preventing the uniform working, by locking the machine, if the valves or flaps open or shut the least too soon. The chief objection to the meters on the gravity principle is the difficulty of any float opening a valve or stop-cock at the proper times to define the proper measurement of the water.

Looking carefully over all these plans, the writer found none so well adapted as the Gas Meter, which is the one shown in the drawings and model; it is as simple as a grindstone, and turns with the least possible weight of water. The velocity is maintained at a rate as nearly uniform as possible by means of the regulating valve, and will pass the quantities denoted on the badges with a pressure of water varying from 2 feet to 400 feet.

Figure 1, Plate 19, is a front view of the Meter, showing the regulating valve. Figure 2 shows the internal drum, and Figure 1 Plate 20, is a transverse section of the Meter.

A is the inlet valve in the supply pipe which is opened by the ball-cock B, when the water is lowered in the small cistern C, from which the water is supplied for use over the building. D is the regulating valve for maintaining a uniform level of water in the Meter; it is opened by the float E, and is constructed with a piston F upon the valve spindle of the same area as the valve, which balances the pressure on the valve, so that it is not affected by the pressure of the water in the supply pipe, and is easily opened or shut by the float F, however great that pressure may be. The guard plates G check the force of the water passing the valve, preventing the water in the Meter from being agitated.

The drum H is similar to that of a Gas Meter with four compartments, formed by oblique radiating plates which overlap each other nearly half round the drum, and each of the compartments opens into the outer space I of the drum into which the water is poured, and from which the water enters each compartment in succession. The water escapes on the opposite of the drum into the trough K, and in passing through the drum, turns it round, as the oblique position of the divisions removes the outlet opening of each compartment nearly half a revolution from its inlet. The drum revolves freely in the trough K, and the water flows through it with very slight resistance, registering itself by the revolution of the drum as it passes through, and then overflows the side of the trough K and passes into the supply cistern C. The spindle of the

drum moves wheelwork by the worm L, like a gas meter to register the number of gallons on a dial. The trough K is suspended by the hoop M, with an adjusting screw N at the top, by means of which it can be raised or lowered so as to adjust the meter accurately in measurement, as the quantity of water that the drum measures in each revolution depends upon the depth of its immersion in the trough, the deeper it is immersed the more water it takes to turn it round, and *vice versa.*

The velocity of the Meter should be kept tolerably uniform, as the trough which holds the water will vary a trifle when a large quantity is supplied into it than a smaller quantity. This is but a trifle as the overflow is all round the trough, and therefore the meter is made to measure the water correctly when going rather below its full speed, which, when used at full speed gives a trifle over, but less than one per cent., in favour of the consumer.

Mr. Clift observed, that he had carefully tested this meter, and found that it measured liquids very accurately, and, indeed, small quantities were measured by it more accurately than could be effected by pouring from one vessel into another. It was a very ingenious contrivance, for the valve took off the pressure and allowed the meter to work with a heavy pressure exactly the same as with a small pressure. Meters had heretofore been made to work under pressure, but it became impracticable to use them for common purposes, in consequence of their great expense, caused by the strength necessary to stand the heavy pressure. This meter was placed at the top of the building, and registered the water that passed down to supply the house; the cistern below was always kept full, and not more than full, in consequence of the float valve, which stopped off the supply when the water was not being used. He had been informed by Mr. Parkinson, (who was unable to attend the present meeting), that he had so many applications for these meters from different Water Works Companies that he could not supply them fast enough. The Sanitary Commissioners had recommended the employment of meters for the supply of water to all small houses in large towns, as the small consumers were at present supplied at a higher rate than others ; and it was probable that some meter would ultimately be adopted by all Water Companies.

The CHAIRMAN thought it very likely that this plan of measuring water would be very useful, and a meter was much wanted, particularly to those who purchase large quantities of water, as was the case for railway purposes where there was only the imperfect means of measurement into tanks, for ascertaining the quantity consumed.

The thanks of the meeting were voted to Mr. Parkinson for his communication; and the following paper by Mr. R. Peacock, of Manchester, was then read:—

ON THE WORKSHOPS FOR THE LOCOMOTIVE CARRIAGE AND WAGGON DEPARTMENTS OF THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

These works are erected at the first point from Manchester where the Railway and the land take the same level, viz.: at Gorton, about two miles from Manchester, this being considered the best position from its being near the principal terminus of the Company's Lines, and from the facility with which materials can be procured and workmen engaged; and though it is a terminal establishment, with the advantage of being situated near enough to a First-class Mechanical Town to secure any benefit that may be had therefrom, it is sufficiently far out of it to be clear of the heavy local taxes with which such establishments in all large Towns are burdened.

The site was fixed upon, and land purchased to construct Workshops for the Sheffield and Manchester Railway only; but subsequent to the amalgamation of that Company with the net-work of Lincolnshire lines, and which now form the Manchester, Sheffield, and Lincolnshire Railways, more land was purchased and the Workshops increased in size to meet the wants of the joint Companies. The total quantity of land purchased is nearly Twenty Acres, about Nine of which is occupied by the Workshops and Storeyard, and the remainder is being used for the construction of Reservoirs for supplying the works with water, and for erecting Cottages upon for the workpeople in the Company's service.

The block plan, Plate 21, shows the general arrangement and relative positions of the Shops, Cottages, Reservoirs, &c., the plot of land being bounded on the south by the Railway, on the east by the Peak Forest and Macclesfield Canal (also belonging to this

Company), and on the north adjacent to the Manchester and Ashton-under-Lyne highroad. The Reservoirs are calculated to hold a month's consumption of water, and are supplied from the adjoining Canal, the water passing through filter beds in its course from the Canal to the Reservoirs. These Reservoirs from their elevated position supply the water directly into the Tenders upon the Railway and throughout the Workshops, their position being sufficiently high to do this, and the Canal high enough to supply the Reservoirs. The Cottages shown on the plan are 140 in number, arranged in four blocks; and between the Cottages and Reservoirs, and the Workshops, is a plot of vacant land that may be used for increasing the number of Cottages, or for any other purpose that may be hereafter required.

The plan of the works is nearly that of a square, the Watch-house or entrance being situated towards the Cottages on the east side of the works, as also is the rail entrance, and adjoining are the Offices and General Stores.

The Engine-house or shed for working Engines, Plate 22, is a rotunda of 150 feet in diameter inside, and will hold seventeen Engines with their Tenders, leaving the entrance and exit lines clear. The advantage in this description of building over the ordinary polygon is in the absence of pillars for supporting the roof, there being but one in the rotunda, while in the polygon, say of twelve sides, there would be twelve, and the number of pillars would determine the number of lines and consequently the number of Engines it will hold, while in the rotunda the number of lines is with the number of Engines, influenced only by the clearance required for each other; thus, the polygon would hold eleven engines with the entrance clear, while the rotunda will hold seventeen.

To the left of the entrance is a furnace for lighting up the Engines from, and the points for the two lines to the table are set so that the Engines will (on entering) go upon the right hand side of the pillar; and thus, supposing them to enter Engine first, they *must* be backed into each line, which will cause the smoke box, or chimney end of the Engines, to be always nearest the table, and consequently in a right position for the tubes &c. being cleaned.

The turntable in the centre is 40 feet diameter, with two lines of rails upon it, one upon each side the Centre Pillar around which it moves The centre pillar is of cast iron, the base forming the bed

for the inner rollers of the turntable to revolve upon; the top of the pillar is sufficiently large to receive the shoes for carrying the principals of the roof, and to which they are secured by bolts, each principal radiating from the centre of the pillar, and its opposite end resting upon the outer wall of the building. A collar is cast upon the pillar about 8 feet from the top, which was intended to carry one end of a circular travelling frame; the frame being intended to revolve round the pillar, and the opposite end having a carriage running upon a circular rail beam, which was to have been supported by the pilasters built on the inside of the walls, the frame being surmounted by a travelling crane in the usual way; this however has not yet been carried out. The roof is of wrought iron, surmounted by a louvre, the top of which is glazed; the whole forming a beautifully ventilated and well-lighted building.

To the left of the rotunda are the workshops, with Engine-house, boiler, &c. The Fitting and Tool Shop is 120 feet by 60 feet, and contains the whole of the Tools, with the exception of the Punching and Shearing Machines. Two rows of Fitter's Benches are erected near the far end; the Lathes, Drills, &c., are placed down each side, and have their counter shafts carried by wall plates, built into the side walls, and the Planing Machines are placed in the centre, the whole being driven from two lines of Main Shafting passing longitudinally down the shop, one over the vertical shaft from the Engine, and the other equidistant from the opposite wall, this shaft being continued over the Shop Stores and passing over the Travelling Platform into the Carriage Shed for driving the Hoist therein. The Smith's Shop is next to the Fitting Shop, and is of the same dimensions, 120 feet by 60 feet; it contains a Fan and sixteen Smiths' Fires, eight of which are placed upon each side of the Shop, and if necessary three more can be placed at the ends. Next to this is the Boiler Shop, the same size as the Smithy, in which are erected eight smiths' fires, on the side next to the Smiths' Shop; four boiler fires are placed upon the opposite side, and the punching and shearing machines at the entrance end, these and the fan being driven by a shaft passing from the Engine transversly across the ends of the shops. Adjoining to the left and at right angles with these is the Erecting Shop, which is 150 feet by 60 feet, in this are nine transverse lines of rails, each line holding two engines, down each side and the centre are pillars supporting longitudinal beams for carrying the Travelling Cranes one

upon each side ; both these Cranes traverse the full length of the shop, and are each calculated to lift an Engine and move it to any part of the shop, if necessary.

To the left, and bounding the west side of the works, are the Waggon and Carriage Shops, the Waggons being on the ground-floor and the Carriages above; the carriages are lifted up and down by a self-acting worm-hoist, worked by the shop Engine. These rooms are 320 feet by 70 feet, the Carriage shop will hold thirty-eight carriages, and the ground-floor about fifty waggons; at the end of these are the lifting-room below, and the Trimming and Saddlery room above, each 60 feet by 70 feet. The lines in the lifting and waggon shops are served in common with the erecting shop by a travelling platform, 20 feet by 12 feet, running upon three rails at right angles with the lines in the shops.

Opposite the lifting-shop, and forming part of the south boundary, is a paint shop, 60 feet by 40 feet, and in continuation of this is a shed for working stock not required for present use; this shed is 165 feet by 40 feet, and may be used for working engines if necessary. In a line with this and at the south east corner of the works is the Coke Shed, 100 feet by 40 feet; this is so constructed that the Coke Waggons are on one side and the Engine on the other, the Coke being filled into baskets upon a platform between the Engines and Waggons, and transferred from thence to the Engines, the waggon line side of the shed is closed, as also the ends, but the Engine line inside of the shed is open, the roof merely projecting over the Engines, where they are being coked.

The arrangement of the lines into and in the works, with the four sidings running parallel with the railway outside, is shewn by the block plan, Plate 21.

Mr. Peacock observed, they had never experienced the slightest difficulty with the turn-table in the rotunda, or the two lines, during the two years that they had been at work. There was no danger arising from a want of balance on the turn-table when only one line was loaded with an engine, because each line of rails was carried by an independent pair of girders, supported by rollers, and joined together in the centre. They could turn an engine upon the table in about a minute, with three men,

and it was sometimes done by two cleaners. The object in the arrangement had been to get as many engines in as small a space as possible, and they could find no other shape so well adapted for the purpose, or into which so many engines could be got in proportion to the area, with the same convenience and room for getting about them. The total area of the floor of the building is a little over 17,000 square feet, which is equal to 1,000 square feet of shed surface per Engine accommodated, with ample room to get conveniently around each, and leaving the entrance and lines clear.

Mr. DOCKRAY did not see what was gained by the oblique arrangement. At Camden-town the rotunda was 160 feet in diameter, and held 24 engines on the old arrangement, the space allowed for an engine and tender being 50 feet in the centre to turn. If the columns in that arrangement were placed sufficiently far back to get a clearance between the engines, he considered they would not lose any space.

Mr. PEACOCK observed, that although the columns might be put so far back as to clear the lines, columns were always very objectionable and inconvenient at the side of the engines, and he thought the central column much preferable.

Mr. COWPER suggested, that with a roof of only 150 feet span, the columns might be entirely done away with, and the cost not be increased more than £1 per square.

Mr. PEACOCK observed, with respect to lifting the carriages into the upper shop, that it was effected in two minutes by the worm hoist; the time was not an object of importance, as there were only about two carriages raised per day.

Mr. GIBBONS suggested, that the air-lift might be very advantageously employed for the purpose. By a very small abstraction of power continuously going on they would procure a reservoir of power of large amount ready to be applied when requisite, and be enabled to lift the carriages in a quarter of a minute. There was one advantage in the employment of compressed air, that it was more under command than any other power, and more easily regulated.

Mr. PEACOCK did not think that plan could be applied economically in the present case, as it would involve the expense

of a large reservoir; the object had been to get something to answer the purpose as simple and cheap as possible, and the only apparatus employed was a 1-foot worm working into a 4-feet worm-wheel.

The CHAIRMAN proposed a vote of thanks to Mr. Peacock, which was passed; and the following paper, by Mr. F. Bramwell, of London, was then read:—

ON AN IMPROVED VACUUM GAUGE FOR CONDENSING ENGINES.

Figure 2, Plate 20, represents the ordinary Long Vacuum Gauge where the mercury is contained in an uncovered cast-iron cup, in which is immersed a glass tube, open at the bottom end, but sealed at the top. A small iron pipe, with a stop-cock and connection to the Condenser, passes through the mercury, and up the glass tube nearly to the top. By this pipe the air is exhausted from the glass tube, and the mercury rises in it in proportion to the difference between the pressure of the atmosphere, and of the uncondensed vapour in the condenser. The objections to this gauge are, firstly—that it does not indicate the real pressure of the uncondensed vapour remaining in the Condenser, unless there is an opportunity of comparing it with a barometer; and, secondly—that the mercury is frequently drivenout and lost, by the stop-cock being left open, while blowing through previous to starting. These Gauges are also of necessity cumbrous, as they must be nearly 3 feet long, to shew the higher vacuums of 29 and 30 inches.

Figure 3, Plate 20, represents the Ordinary Short Vacuum Gauge, where a small glass tube closed at the top contains the mercury, and at the bottom is bent upwards, ending in a bulb which has a small orifice on its upper side. This tube is carefully filled in the same manner as the ordinary barometer, and is then attached to a scale entirely enclosed in a glass case, which is cemented to a brass cup, terminating in a stop-cock and a pipe, by which the connection is made with the Condenser, so that the air in the interior of this case is always at the same density as that in the Condenser; and as the mercurial tube is only from 8 to 10 inches long, it is evident that the mercury will be held up in it by the pressure of the air in the glass case, until the density of it is reduced below that, which is equal to sustain a column equivalent to the height of the tube.

By this means, when it is required to shew only the higher degrees of rarefaction, as in steam engines, the gauges may be made extremely short and compact, and it is evident that they will always indicate the total pressure of the uncondensed vapour, irrespective of the state of the atmosphere. For these reasons this gauge has been very extensively used, and no doubt its employment would have been universal, had it not been for two objections. The first and gravest being, that the vapour from the Condenser deposits frequently on the inside of the glass case and forms a mist, and so dense a one, as not only to render it impossible to observe the height at which the mercury is standing, but to see even the scale itself. The second objection is, that if the stop-cock is not shut off previous to blowing through, the inside of the glass becomes filled with steam or hot water, and is very liable to be broken thereby. The joint between the glass case and the brass seat generally leaks, and this to such an extent that the gauge is almost always shut off, to prevent the vacuum being injured by the passage of air into the condenser.

Figure 4, Plate 20, represents the Improved Short Vacuum Gauge. The principle is precisely similar to that of Figure 3, the difference being merely in the arrangement. Instead of immersing the whole of the tube and scale in a glass chamber connected with the condenser, the bulb only is enclosed in a brass cup, with a screw lid (on which the scale is cast), and the rest of the mercurial tube is passed through a stuffing box in the middle of this lid, protecting it from injury by sinking it in a depression in the scale like a common thermometer. On the bottom of the brass cup is the stop-cock with the pipe, by which connection is made with the condenser, the same density is always preserved in it and the cup ; and thus, the pressure being removed from the surface of the mercury in the bulb, it of course falls according to the rarefaction ; a fall that can be always observed, as the tube containing the mercury is totally uncovered. By this means the first and great objection to the short vacuum gauge is done away, and likewise the second which is common to both long and short, viz.—the risk of the stop-cock being left open while blowing through ; as with this gauge it is a matter of perfect indifference whether it is open or not, as the only thing that takes place if it is open, is that the brass closed cup is filled with steam, but this can neither blow out the mercury nor damage the gauge. In fact, those that the author has at work under his

own control are never shut off. As regards their leakage, he has been taking every pains to get them as tight as possible ; and in this he has so far succeeded that the first one put to work, nearly two years since, on one of the pumping engines, at the Grand Junction Water Works at Brentford, retained the mercury at 29 inches, for a week after the engine stopped, and no doubt would have retained it to the present day, had it not been opened. The stop-cock is made with a hollow plug; this is done for neatness, and also to diminish the risk of leakage, as one end of the plug is by this arrangement contained in the pipe leading to the condenser. This could not conveniently be done with any other gauge, as there are none, it is believed, sufficiently light and compact to be carried by one point of support only, and that the plug of a cock. The author first had these gauges made in January, 1849, and since then about thirty or forty of them have been adopted, and it is understood are all giving satisfaction.

The above method of arranging the short vacuum gauge appears to be so obvious a one, that the author is quite prepared to hear that it is not a novelty to some of the members, although certainly one to himself. It may be observed, as an apology for introducing such a simple matter, that the alteration in the arrangement, trifling as it is, has produced a neat and cheap instrument, that answers perfectly, in place of a rather unsightly and expensive one, that was frequently utterly useless from its being obscured by vapour condensing in it.

Mr. COWPER observed, that the instrument was very efficient for the purpose intended. He could speak practically on this point, for it was not new to him, although he was not before aware of the existence of Mr. Bramwell's invention. For three years he had had a pair of the same construction in use at Fox, Henderson, and Co.'s Works. They worked extremely well, and there was no necessity for shutting off the cock ; he believed it was the idea of Mr. Field, of Birmingham, by whom those instruments were made.

The CHAIRMAN thought that the instrument, though a simple alteration, was certainly a valuable improvement.

Mr. ADAMS remarked, it was interesting to find different minds, when applied to the same practical subject, arriving at the same result.

The thanks of the meeting were voted to Mr. Bramwell, for his communication; and the following paper by Mr. Barrans, of London, was then read :—

ON AN IMPROVED AXLE BOX FOR RAILWAY ENGINES AND CARRIAGES.

The attention of the writer was first drawn to the present subject by the wearing of the Axle Bearings at their ends, and the great number of brasses that were in consequence thrown aside as useless before being half-worn through, the expense of repairing such as were retained for work, and the loss of time, as well as expense, incurred by the necessity of lifting both Engines and Carriages for the purpose of either renewing or repairing, and replacing the bearings so worn; and in the consideration of this subject it becomes evident that some portion of the accidents and a large amount of expense are to be attributed to this great source of mischief.

The Engines and Carriages in the early part of their work, whilst the journals and wheels as well as the road are true, run steadily without deviating from the line of their course, whether straight or curved; but the friction of the shoulder and collar of the journals against either end of the bearings causes wear upon the latter which increases in proportion with the amount of wear. A new motion endways of the Axle takes place, which, aided by the superincumbent weight, causes the shoulders and collars to strike as well as revolve, and to beat up the metal, which is then peeled or turned off by the subsequent revolution of the shoulder or collar against the bearing; hence a twofold cause of destruction is created and actively in progress, the rate accelerating with the progress. This work of destruction goes on until to avoid danger to the passengers or rolling stock, or complaints of discomfort, it becomes necessary to put a stop to it either by fitting in new bearings, or by turning up, or otherwise repairing the old ones. The turning up of the wheels of both Engines and Carriages is a work of frequent occurrence, occasioned by the rubbing or grinding of the tire, and striking of the flanges of the wheels against the rails, which observation and experience have proved to originate in the endway motion of the axles. That the expense incurred in rectifying this mischief forms a not unimportant item in railway expenditure, and the loss of time occasioned by it a

cause of considerable delay, is well known. Also the excess of endway motion being once commenced, its effects are ere long shewn in the derangement of the Permanent Way; and, as soon as the Permanent Way becomes out of order, its very derangement in itself becomes a cause of mischief, and combines in the general derangement and destruction of both way and machinery.

Another evil of the endway motion in axles is the oscillation produced in the Engines and Carriages, which contributes by constant shaking and vibratory motion to the excess of wear, and the loosening of all the joints of their machinery, and adds to the force of the blow with which the flanges of the wheels strike against the rails, creating undue straining upon the guide plates, and tending to their fracture and excessive wear. This also adds to the chances of breakage of the axles by the lateral strain from the flanges of the wheels suddenly striking the switches and crossings in passing through them, as well as the main rails; the effect of that sudden striking or blow being so much greater, and of so much more dangerous tendency, when it is aided by the weight of the vehicle and its load, and risking not only the probability of the fracture of the axle, but also of the vehicle when at high velocity getting off the line. This oscillation also occasions much discomfort to passengers, and ground of complaint. Every time the flange of the wheel strikes against the rail, the speed of the vehicle is checked, and the progress of the train retarded, unless the check received be overcome by the exertion of a greater amount of propelling power than would otherwise be required; hence a necessity arises for greater consumption of fuel, and a consequent increased expense is occasioned: and it may be remarked also, that by the shaking of the Engine arising from the endway motion of the axles, and the concussions of the flanges of the wheels against the rails, much of the firing is from time to time shaken out of the fire box, and wasted on the road, thereby adding to the consumption of fuel.

Fig. 1, Plate 23, shews a section of the Improved Axle Box. B is the *end bearing-piece*, fitted to slide in the boss L, and capable of being adjusted to any required distance from the end of the axle A, so as to allow the latter to revolve without friction, and at the same time preventing any excess of endway motion. The end of the axle is a little rounded, and is lubricated through the hole immediately above it; the bearing-piece acts *eccentrically* against

the end of the axle when in contact with it, for the purpose of ensuring its constant lubrication. The adjustment is effected by the hand pushing up the bearing-piece to the end of the axle, and then withdrawing it a short distance, so as to leave merely a slight working clearance between the two; it is then fixed in its place by the point of the set-screw E entering one of the holes F, which are arranged in a spiral form round the bearing-piece, so as to allow of its being adjusted to 1-32nd inch; the set-screw is kept in its position by a jam-nut.

Fig. 2 shews a method of applying the principle to existing axle boxes of railway stock, by bolting the boss L on to the front of the axle box.

Figs. 3, 4, and 5, shew various modifications of the same principle. In Fig. 3, the end bearing-piece B is adjusted by means of the screw-socket C, which is fixed by a jam-nut and set-screw; in this case the end collar of the axle journal is dispensed with. In Fig. 4 the adjustment is effected by the wedge D; and in Fig. 5 the end bearing-piece B is made in the form of a wedge and slides between two guide-pieces, being pressed up by a screw. Several other modifications are employed to facilitate the application of the principle to the various patterns of axle boxes, either new or old.

The modification shewn in Fig. 3 is, (with the exception of the Grit shield) that in which the improved Boxes were first applied upon the leading and trailing wheels of the Brighton Express Engine, which has worked with them upwards of 10,000 miles; and also upon a Carriage on the South Eastern Railway, where the bearings were purposely made half an inch too short, to resemble worn bearings, by which means in a journey from London to Dover and back, the fact of its oscillation was first manifested, and in the course of the return to London, during a short stoppage at Ashford of the train in which it ran, the end bearing-pieces were adjusted, and the oscillation consequently ceased; one of the axle boxes from this carriage is laid before the Meeting. The Engines to which the improved Boxes have been applied, have become in consequence so much steadier in running, that the full speed can be safely maintained over bad parts of the road, where before it was necessary to slacken speed. An important advantage is the facility with which the adjustment can be effected whenever required, without taking the engine or carriage out of the train.

The next point is the Grit and Dust that is thrown up by the wheels or by the wind, finding their way between the journals and their bearings;—the injury done by this cause is manifest in the result of heated axles and bearings, with their concurrent excessive derangement and wear, and the delays and expense attendant upon this mischief, and to remove this, the Grit Shield is designed in the Improved Axle Box. The circular ring S is attached by two screws to the inner face of the axle box, and the corresponding ring T is keyed upon the axle and revolves with it; the flanges of these shields interlock with each other without touching or causing any friction, and prevent any grit or dust from passing between them and getting to the journal. The grit shield is not applicable to Engines under the present form of their wheels and axles.

The object of the remaining portion of the invention is to prevent the waste of the lubricating material used for the journal bearings, that occurs in the ordinary axle boxes, and to save the tallow and oil used for this purpose and work it over and over again, thus materially reducing one important item in the working expenses. An under cap is slipped up into the lower part of the ordinary boxes and fixed there by bolts passing through the sides; this under cap (which in new axle boxes is cast in one with the box) forms the receptacle for the cast-iron Grease Drawer H, which slides in the lower part of the axle box and is secured by the spring catch K. The lubricating material passing over the journals, falls into the drawers, and may whenever necessary, by turning over the contents of the drawer into the top of the box, be used again and again, until its lubricating properties have become deteriorated; when, by heating it gently in a vessel with a small quantity of water, the extraneous matter will sink to the bottom, and the grease and oil be separated at the top, purified and again fit for the purpose of lubrication. By this means the large amount of saving has resulted in practice of from 5-6ths to 7-8ths of the tallow and oil passed over the journals, the material proving afterwards even of a better lubricating quality than at first, from the ingredients becoming more amalgamated.

There is another material advantage attending this part of the invention, inasmuch as Oil, which is generally admitted to be a better lubricator, and more certain in its action than grease of any kind, has been mostly kept out of use, by reason of the great waste

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attending it in ordinary axle boxes, and its being inapplicable in others; but in these improved boxes, the whole material being caught in the grease drawer, and again returned into the box, oil may be applied with great economy and advantage, always being ready and keeping up its gradual and constant supply; whereas with grease of any kind the axle must have become heated sufficiently to melt the grease before the latter can come into operation; and thus a serious mischief will have commenced, which by very small increase will, and does in practice, rapidly melt and allow to run away the only means by which the heat can be kept in subjection, and frequently gives rise to lifting and repair and throwing the vehicle out of work. Also in these improved boxes, by merely taking out the grease drawer, a convenient means is at once afforded of examining the state of the journals and boxes, which, with the ordinary boxes, it would require lifting to accomplish.

Mr. BARRANS exhibited specimens and models of the improved axle boxes, and specimens of the grease that had been used once and three times respectively; also certificates of the saving in tallow and oil, amounting to 3-4ths, and 7-8ths, that had been ascertained in a trial with these axle boxes on an Engine on the Brighton Railway, and a Carriage on the South Eastern Railway.

Mr. ADAMS remarked, that he had found that waggons and carriages did not work well unless there was plenty of end-play in the bearings; for if fitted up very close they were liable to heat. In the case of waggon bearings, he thought a play of 3-16ths of an inch was requisite.

Mr. WRIGHT was of opinion that the more play was left in the bearings the more would be the wear; he thought 1-16th inch was abundant.

Mr. HENSON observed, that he did not leave any end-play in waggon bearings; on the contrary, so accurately were they adjusted, that red lead, or something of the kind, was employed to ascertain the complete fit; in fact, they too soon acquired the play in the course of work. The only thing of importance was

the grit, but with reference to that they had scarcely any trouble, and in a stock of 2,500 waggons they very rarely had cases of hot journals. He used a very large grease chamber, and hence, although there was a large quantity of grease present, the bearing was kept so cool that there was very little demand for it.

The further discussion of the subject was adjourned to the next meeting, and a vote of thanks was passed to Mr. Barrans for his paper.

The Meeting then terminated; and in the evening a number of the members and their friends dined together.

SUBJECTS FOR PAPERS.

STEAM ENGINE BOILERS, particulars of construction—form—heating surface—cost—consumption of fuel—evaporation of water—pressure of steam—steam gauges, high pressure and low pressure—explosion of boilers and means of prevention—effects of heat on the metal of boilers, low pressure and high pressure—incrustation of boilers and means of prevention—evaporative power and economy of different kinds of fuel, coal, wood, charcoal, peat, patent coal, and coke—smoke consuming apparatus, best plan and results of working.

STEAM, expansive force and best means of using it—power obtained by various plans—comparison of double and single cylinder engines—indicator figures from engines, with details of useful effects, consumption of fuel, &c.—contributions of indicator figures for a general book of reference to be kept in the Institution.

PUMPING ENGINES, particulars of various constructions—size of cylinder, strokes per minute, and horse power—number and size of pumps and strokes per minute—application of pumps—fen draining engines.

BLAST ENGINES, best kind of engine—size of cylinder, strokes per minute, and horse-power—number of boilers—size of blowing cylinder and strokes per minute—means of regulating the blast—improvements in blast cylinders.

MARINE ENGINES, power of engines in proportion to tonnage—different constructions of engines—comparative economy and durability of different boilers, tubular boilers, &c.—weight of machinery and boilers,—kind of paddle wheels—speed obtained in British war steamers, in British merchant steamers, and in Foreign ditto, with particulars of the construction of engines with paddle wheels, &c.—screw propellers, particulars of different kinds, number of arms, material, means for unshipping, horse-power applied, speed obtained, section of vessel.

ROTARY ENGINES, particulars of construction and practical application—details of the results of working.

LOCOMOTIVE ENGINES, express, passenger, and luggage engines—general particulars of construction, details of experiments, and results of working—speed of engines, cost, power, weight, steadiness—consumption of fuel—heating surface, length and diameter of tubes—experiments on size of tubes and blast pipe—comparative expense of working and repairing—best make of pistons, valve gear, &c.

ENGINES worked by Gas, Gun-cotton, or other explosive compounds.

ELECTRO MAGNETIC ENGINES, particulars and results.

WATER WHEELS, particulars of construction and dimensions—form and depth of buckets—head of water, velocity, per centage of

power obtained—scoop wheels for draining—turbines, construction and practical application, power obtained, comparative effect and economy.

WIND MILLS, particulars of construction—number of sails, surface and form of sails—velocity, and power obtained—average number of day's work per annum.

FLOUR MILLS, particulars of improvements—power employed—application of steam power—results of working with an air blast—advantages of regularity of motion.

SUGAR MILLS, particulars of the construction and working—results of the application of the hydraulic press in place of rolls.

SAW MILLS, particulars of construction—mode of driving—power employed—particulars of work done—best speeds for vertical and circular saws—form of saw teeth—saw mills for cutting ship timbers.

OIL MILLS, facts relating to the construction and working.

COTTON MILLS, information respecting the construction and arrangement of the machinery—power employed, and application of power—cotton presses, mode of construction and working, power employed.

MACHINERY for manufacturing Flax, both in the natural length of staple and when cut.

ROLLING MILLS, improvements in machinery for making iron and steel—mode of applying power—steam hammers—piling of iron—plates—fancy sections.

STAMPING AND COINING MACHINERY, particulars of improvements, &c.

PAPER MAKING AND PAPER CUTTING MACHINES,	ditto	ditto.
PRINTING MACHINES,	ditto	ditto.
CALICO PRINTING MACHINERY,	ditto	ditto.

WATER PUMPS, facts relating to the best construction, means of working, and application—best forms—velocity of piston.

AIR PUMPS,	ditto	ditto	ditto.

HYDRAULIC PRESSES, facts relating to the best construction, means of working, and application.

FIRE ENGINES,	ditto	ditto	ditto.
SLUICES,	ditto	ditto	ditto.
CRANES,	ditto	ditto	ditto.
STEAM CRANES,	ditto	ditto	ditto.
LIFTS FOR RAISING TRUCKS, &c.	ditto	ditto	ditto.

LATHES, PLANING, BORING, AND SLOTTING MACHINES, &c., particulars of improvements—description of new self-acting tools.

TOOTHED WHEELS, best construction and form of teeth—results of working.

DRIVING BELTS AND STRAPS, best make and material, leather, rope, gutta percha, &c.—comparative durability and results of working—power communicated by certain sizes.

STRENGTH OF MATERIALS—facts relating to experiments on ditto, and general details of the proof of girders, &c.—girders of cast

and wrought-iron, particulars of different constructions, and experiments on them—best forms and proportions of girders—best mixtures of metal.

DURABILITY OF TIMBER of various kinds—best plans for seasoning timber and cordage—results of Kyan's, Payne's, and Burnett's process—comparative durability of timber in different situations.

CORROSION OF METALS by salt and fresh water, and by the atmosphere, &c.—facts relating to corrosion, and best means of prevention.

ALLOYS OF METALS—facts relating to different alloys.

FRICTION OF VARIOUS BODIES—facts relating to friction under ordinary circumstances—friction of iron, brass, copper, tin, wood, &c.—proportion of weight to rubbing surface—best forms of journals, &c.—lubrication, best materials and means of application, and results of practical trials—best plans for oil tests.

IRON ROOFS, particulars of construction for different purposes—durability in various climates and situations—comparative cost, weight, and durability—roofs for slips of cast-iron, wrought-iron, timber, &c., best construction, form, and material.

FIRE-PROOF BUILDINGS, particulars of construction—most efficient plan—results of trials.

CHIMNEY STACKS of large size, particulars, mode of building, &c.

BRICKS, manufacture and durability—fire-bricks and fire-clay.

GAS WORKS—best form, size, and material for retorts—construction of retort ovens—quantity and quality of gas from different coals—improvements in purifiers, condensers, and gas holders—wet and dry gas meters—pressure of gas, gas exhauster—gas pipes, strength and durability, and construction of joints—proportionate diameter and length of gas mains, and velocity of the passage of gas—experiments on ditto, and on the friction of gas in mains and loss of pressure.

WATER WORKS—facts relating to water works—application of power, and economy of working—proportionate diameter and length of pipes—experiments on the discharge of water from pipes, and friction through pipes—strength and durability of pipes, and construction of joints.

WELL SINKING and ARTESIAN WELLS, facts relating to.

COFFER DAMS and PILING, facts relating to the construction.

PIERS fixed and floating, and Pontoons, ditto ditto.

PILE DRIVING APPARATUS, particulars of improvements—use of steam power—facts relating to Pott's apparatus.

DREDGING MACHINES, particulars of improvements—application of dredging machines—power required, and work done.

DIVING BELLS, facts relating to the best construction.

CAST-IRON LIGHTHOUSES, ditto ditto.

MINING OPERATIONS, facts relating to mining—means of ventilating mines, use of steam jet and ventilating machinery—mode of

raising materials—mode of breaking, pulverizing, and sifting various descriptions of ores.

BLASTING, facts relating to blasting under water, and blasting generally—use of gun cotton, &c.—effects produced by large and small charges of powder.

BLAST FURNACES—consumption of fuel in different kinds—burden, make, and quality of metal—pressure of blast—horse power required—economy of working—improvements in manufacture of iron—comparative results of hot and cold blast.

HEATING FURNACES, best construction—consumption of fuel, &c.

SMITHS' FORGES, best construction—size and material—power of blast.

SMITHS' FANS, and FANS generally, with facts relating to the amount of power employed, and the effect produced.

COKE and CHARCOAL, particulars of the best mode of making.

RAILWAYS—construction of permanent way—section of rails, and mode of manufacture—experiments on rails, deflection, deterioration, and comparative durability—material and form of sleepers, size, and distances—improvements in chairs, keys, and joint fastenings.

SWITCHES and CROSSINGS, particulars of improvements, and results of working.

TURNTABLES, particulars of various constructions and improvements.

SIGNALS for Stations and Trains, and self-acting signals.

BREAKS for Carriages and Waggons, best construction.

BUFFERS for Carriages, &c., and Station Buffers—different construction and materials.

SPRINGS for Carriages, &c , buffing and bearing springs—particulars of different constructions, and results of working.

RAILWAY WHEELS, wrought-iron, cast-iron, and wood—particulars of different constructions, and results of working—comparative expense and durability—wrought-iron and steel tires, comparative economy and results of working.

RAILWAY AXLES, best description, form, material, and mode of manufacture.

The Council invite communications from the Members and their friends, on the preceding subjects, and on any Engineering subjects that will be useful and interesting to the Institution; also presentations of Engineering drawings, models, and books for the library of the Institution.

The communications should be written on foolscap paper, on one side only of each page, leaving a clear margin on the left side for binding; they should be written in the third person. The drawings illustrating the communications should be on so large a scale, as to be clearly visible to the meeting at the time of reading the communication, or enlarged diagrams should be sent for the illustration of any particular portions.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the year ending 31*st December*, 1850.

Dr.	£	s.	d.
To Subscriptions from 16 old Members, being Arrears for 1849	48	0	0
„ ditto from 150 old Members for 1850	450	0	0
„ ditto from 13 new Members for 1850	65	0	0
„ ditto from 3 new Graduates for 1850	9	0	0
„ ditto in advance for 1851	3	0	0
„ Donation from R. Stephenson, Esq., M.P.	100	0	0
„ Sale of Extra Reports	1	6	0
„ Balance from 31st December, 1849	195	11	3
	£871	17	3

Cr.	£	s.	d
By Stationery, Printing, and Engraving	76	6	0
„ Alterations of Building for Meeting Room, and Offices and Gas-fittings	71	11	6
„ Furniture for ditto	32	1	5
„ Office Expenses and Petty Disbursements	26	5	9
„ Travelling Expenses	2	11	9
„ Reporting	12	9	0
„ Parcels	7	7	10
„ Postages	22	1	6
„ Salary	300	0	0
„ Rent and Taxes	90	19	6
„ Balance	230	3	0
	£871	17	3

(Signed) J. E. CLIFT.
WM. BUCKLE.
ARCHIBALD SLATE.

15*th January*, 1851.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 23RD APRIL, 1851.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:

PRINTED AT M. BILLING'S STEAM PRESS OFFICES,

74, 75, & 76, NEWHALL STREET.

1851.

PROCEEDINGS.

THE GENERAL MEETING of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, 23rd April, 1851, J. E. McCONNELL, Esq., Vice-President, in the Chair, in the unavoidable absence of the President.

The Minutes of the last General Meeting were read by the Secretary, and confirmed.

The CHAIRMAN announced that the Institution had been presented, by Mr. Peter Hollins, of Birmingham, with a copy of the bust that had been executed by him of the great engineer, Telford.

The following supplementary paper by Mr. Joseph Barrans, of London, was then read:—

ON AN IMPROVED AXLE BOX FOR RAILWAY ENGINES AND CARRIAGES.

The construction and object of the improved Axle Box are explained in the previous paper, read at the last meeting of the Institution; (see Report of Proceedings, January 22nd, 1851, and Engravings, Plate 23;) the improvements consisting of an End Bearing-piece, of different constructions, to suit the various circumstances of engines and carriages, which is adjusted nearly to touch the end of the axle, and to prevent end-play in the journal; also a Grit-shield, to prevent grit or dust getting on to the journal; and a Grease drawer, to catch the lubricating material passing over the journal, and enable it to be used over again with economy.

A modification of the Axle Box for Carriages has since been constructed, to use oil instead of grease, as it is a better lubricating material, and more certain and regular in its action; the oil being always ready, and keeping up a gradual and constant supply, but the grease requires the axle to be partially heated before it is melted, and can flow

on to the journal; the Grease-drawer prevents the waste that would attend the application of oil in ordinary axle boxes. The cover of the box is made with a lip all round the edge, which shuts over the projecting edges of the opening, so as to prevent any of the water used in washing the carriages or otherwise from getting into the box, as the oil being lighter than the water, would otherwise be lost out of the box if the water were allowed to get in.

These boxes have been applied to a Carriage on the South Eastern Line, where it has been working, lubricated with oil only, for the last three months, perfectly cool and steady, and having neither required nor had any attention to the lubrication on any journey between London and Dover, between which places it has run alternately in the Mail and express Trains; and in an accurate experiment, tried for the continuance of a week, during which it ran 1092 miles, it was found that rather less than half a pint of oil had been consumed in lubricating the four boxes. The Dover Mail Engine, with these boxes applied to the leading wheels only, has been working for the last five months lubricated with oil only, and running cool and steady; these boxes have also been working on three Engines on the Brighton Railway, one of which has run with them 14,260 miles, (these Engines being lubricated with oil and grease,) producing great steadinesss of running, and giving perfect satisfaction, which they continue to do to the present time. An experiment on one of these Engines showed that in one week, during which it ran 1004 miles, out of three pounds of tallow and two pints of oil, delivered out of store for lubricating the two leading boxes of that Engine, 3 lbs. 6 oz. of mixed oil and tallow was caught in the grease-drawer, and returned into store, besides a pound of tallow and oil left in the tops of the boxes, thus showing a saving of seven-eighths of the total quantity. These boxes have also since been applied to a first-class Carriage, and to a Break-carriage of the Brighton Express Train, lubricated only with oil, with the old worn bearings continued in the boxes, and in a week's daily running from Brighton to London and back, half a pint of oil only having been supplied to each box; less than one half the quantity so supplied was consumed, and these carriages ran perfectly steady and cool.

Mr. Barrans exhibited a specimen of the axle-box arranged to work with oil; and stated that, by the plan adopted, they found an important saving was effected in the cost of the lubricating material, and in the trouble and attention required for the journals.

Mr. Cowper inquired whether, as the brasses wore, and the adjusting piece was screwed up to follow the wear, there would not be a displacement of the axle-box, and a strain thrown on the axle-guards and the spring-ties?

Mr. Barrans said that there would not be any displacement of the axle-box, as the effect of the adjustment was simply to maintain it always in the same correct position that it had when first started, and to prevent lateral movement taking place when the brasses had worn shorter. He did not allow the adjusting pieces to bear so as to occasion friction, and there was a slight clearance always left at the ends of the axle.

Mr. Slate observed that, when the ends of the brasses were worn, the collars of the journals would be useless.

Mr. Barrans replied, that no collars were required on the journals with his axle-box; and he proposed in new axles to make the journals quite plain without collars, as shown in one of the drawings, (see Fig. 3, Plate 23.)

The Chairman inquired whether they had had any particular comparison of the steadiness of the carriages where this axle-box was used, over the other similar carriages where it was not used?

Mr. Barrans replied, that in the engines where the box was in use, the running was unusually steady; the engine-drivers were able to increase the speed in consequence in passing over the curves and the worst parts of the line; and the guards reported that the carriages ran much steadier than before that are fitted with the improved axle-boxes. He had endeavoured to try a

more accurate comparison by the oscillation of a pendulum across the carriages, but could not succeed in obtaining a result.

The CHAIRMAN said some more definite comparison than the opinions of the men was required, as there were many circumstances to render them erroneous on such a question.

Mr. ADAMS thought they would still have some end-play, from the springing of the axle-guards, or play in the hanging of the springs, although the play was stopped in the bearings.

Mr. BARRANS replied, that the end-play given by the ordinary clearance between the flanges of the wheel and the rails was quite sufficient, without having end-play in two places, which would be of no use; and he thought it was much better to have the end-play only in one place at the flanges of the wheels, where it was unavoidable. He had only one-sixteenth of an inch play in the axle-guards.

Mr. ADAMS said he always sent out carriages with the brasses closely fitted to the journals; but, after a time, they always got end-play, by the wearing away of the metal. He eased the end blow by having a differently formed shoulder to that adopted by Mr. Barrans; instead of a square shoulder, which injured and abraded the metal with the end blows, the shoulders were well rounded with an easy hollow, so as to make the brasses wear longer, and ease the force of the end blows; but with Mr. Barrans' centre pin there would be a sudden end blow.

Mr. SLATE showed, by one of the specimens of brasses exhibited, that the shoulders of the journal were liable to wear into the ends of the brasses.

Mr. HENSON said he had break-waggons at work that had travelled 15,000 to 25,000 miles without the brasses being changed; and at the conclusion of that period some of the brasses were so little worn as to be put in again. These waggons ran so steadily that a small print could be read in them; he objected to any end-play, and considered that he effected the same result as Mr. Barrans without any complication or expense, by making the brasses always a good fit at starting.

Mr. BARRANS showed that, when brasses were worn too much

the end-play would be stopped at once by the adjusting piece, without removing the brasses or lifting the waggon; the clearance was so small at the ends of the axle that there could not be any end blow.

Mr. Henson thought that Mr. Barrans' plan would increase the friction of the axles, and produce complication.

Mr. Sandom said, checking the end play enabled an engine to be driven without slackening speed over the bad parts of the road, and the men who had driven engines, in which Mr. Barrans' invention was in use, stated that they went over the bad parts and crossings without checking speed, which they could not do before that plan was applied.

The Chairman remarked, that such evidence was, of course, very indefinite, and to be received with caution, as the opinions were often formed without sufficient data.

Mr. Henson thought the saving in the brasses would not be worth the expense of applying the apparatus to every axle-box, which would be very considerable in a stock of 2500 waggons on a railway, or 10,000 axle boxes.

Mr. Cowper said, the real question was in the comparative expense of lifting the waggons and changing the worn brasses when they got too much play, or of merely screwing up the adjustment whilst the waggon was still kept at work.

The Chairman observed, that the object of Mr. Barrans' plan was to keep the axles of engines and carriages from getting end-play in the journals and swerving sideways, as in a certain time, whatever care might be taken in the original make, the brasses would wear, and injurious end-play would take place. If they could keep the carriage steady on the axle, prevent that oscillation which more or less generally occurred, and keep the axle bearings always right, instead of gradually wearing away and getting wrong, they would accomplish a great benefit for the railway interests, and the comfort and safety of the public; and if Mr. Barrans' invention prevented the necessity of taking out and

changing the brasses for that purpose, it appeared to be advantageous. It might be, perhaps, that they were not changed soon enough now, on account of the trouble and expense; and it appeared better to keep them always in right adjustment than to allow them to get gradually wrong. He thought Mr. Barrans had taken much pains with the subject, and that the Institution was indebted to him for bringing it before them; some further improvements might perhaps arise in the invention, or some other means be proposed for accomplishing the object.

Mr. Adams suggested the consideration of such a form and depth of shoulder to the journal, as at the end of a series of years, would be in the same position as at the commencement, and that would wear equally at the shoulders and in the middle of the bearing, so as to keep them always in the same adjustment of play as at first.

A vote of thanks was then passed to Mr. Barrans for his communication; and the following paper, by Mr. Benjamin Gibbons, of Shut-end House, near Dudley, was then read:—

ON THE VENTILATION OF MINES.

The public attention has been much more directed within the last three or four years to the Ventilation of Mines, and a knowledge of the general principles has been more extensively diffused; the inquiry before the Committee of the House of Lords in July, 1849 and the Reports of the Mine Inspectors, since published, have thrown some light upon the manner in which most of the Mines are ventilated, and have pointed out some of the erroneous principles upon which many are conducted.

That this Paper may not be extended to an inconvenient length, the Author will confine himself as strictly as possible to the principles which, in his judgement, should never be lost sight of in the Ventilation of Mines, subjoining such illustrations as to some of the deviations in ordinary practice, that may be necessary to make the subject intelligible. He will also confine himself as much as possible to the Thick or *Ten-yard Coal* of the South Staffordshire

District, (varying from 24 to 30 feet in thickness;) observing at the same time that the principles are equally available to the thinner veins of other districts; for it is obvious that it is much more difficult to drain the upper part of the Coal of the great thickness of 30 feet, of its Carburetted hydrogen, than that of thinner veins. This arises from the great *levity* of the Carburetted hydrogen issuing out of the Coal, (which is the explosive Gas found in Coal Mines;) for it will always rise to the highest point as soon as it is released; and it is plain that in excavating Coal of this great thickness, large masses must be detached, and pockets or hollows must be formed, which are instantly filled with this gas, whilst a thin vein in which a level roof can be generally secured or nearly so, can be kept free from accumulations of this gas with much greater facility.

In December, 1846, in consequence of a frightful explosion taking place at Oldbury, the Author was induced to publish a small work which was written *currente calamo*, and which described the principles of Ventilation adopted and practised by him for many years before in the thick and thin mines that were worked under his personal superintendence.

The introduction of the subject was very unpopular amongst the Proprietors of Mines generally, who dreaded the threatened interference of Government with their operations. This Work only professed to enter into the question of the Ventilation of the South Staffordshire Thick Coal; but from the apprehension referred to above, the Author was assailed from all quarters; correspondents from Newcastle-on-Tyne, Newcastle-under-Lyne, Shropshire, North and South Wales, containing Mines of very different character, and which had never been alluded to by him, all united in one general protest against such outrageous innovations; and if he had promulgated a Bull from the Pope, a greater outcry could not have been raised. Some said he was an ignorant innovator; others, a mere plagiarist; but it was generally settled by these worthy philosophers that he did not know what he was talking about, and pretty generally agreed that he was wrong on all points, and right upon none.

The Author will first recapitulate the substance of a part of his

work, stating in addition the results of a confirmed experience upon a much larger scale, and a slight notice and reply to some of the the objections to his plan which had a plausible appearance (for he believes not one was real;) as he has since brought his plan as then described into uniform practice, and the methods of Ventilation that he recommended are now adopted throughout all his Coal and Ironstone Mines in South Staffordshire with complete success, and very satisfactory results both in working the Thick or Ten Yard Coal and the thinner veins.

The numerous and calamitous accidents caused by the Explosion of Gas in Coal Mines, which are unfortunately still so frequent and destructive both of life and property, render it an object of great importance for Mining Superintendents, Engineers and others, to invent some efficient and certain means of preventing the occurrence of these explosions; many plans have consequently been in practice for accomplishing this object, both by mechanical contrivances and by self-acting natural means.

That many sources of possible accident, and many of them beyond control, will still remain, especially in working a Coal of thirty feet in thickness, is most true; but it is the more incumbent, on this account, upon the managers of Collieries to provide the best practicable means against those dangers which they alone can remedy, especially that most appalling of all dangers, the imperfect Ventilation of the Mines. This danger being removed, a great diminution of the other accidents which indirectly arise from it would soon be experienced; and the Author is fully convinced, from the experience of many years, that this danger may be at once greatly diminished, and eventually almost entirely prevented.

The Carburetted Hydrogen Gas, which produces these dreadful explosions, is not explosive until it is united with a certain proportion of ordinary Air, say seven to nine times its volume; when this mixture has taken place, it arrives at what is termed its "firing" or explosive point, and in that state, if it come in contact with the flame of a candle, it will instantly explode with similar rapidity and violence to gunpowder. A considerable volume of this Gas is set at liberty in all the Thick Coal Mines, when worked in the usual manner, and as often as fresh masses of coal are cut through. Some

Coal Mines supply a much larger quantity of Gas than others, and these are commonly called "Fiery Mines;" but in all Coal Mines a sufficient quantity is extricated to produce the most direful consequences, if it be not neutralised, or its escape duly provided for.

The general mode is that of diluting the Gas with a quantity of atmospheric Air; and a current of Air equal to thirty times the volume of Gas yielded by the Coal is, in the Author's opinion, the bare limit of safety. That is to say, thirty cubic feet of common Air must circulate through the Mine in the same space of time that the Coal will give out one cubic foot of Gas; but the quantity of Air should exceed this where this mode of Ventilation is practised, for a copious supply of fresh Air is needful for the numerous workmen, horses, and candles, employed in the pit.

Many mechanical plans have been recommended to increase the current of Air through the Mines for this purpose; some have recommended Air pumps to force Air in, others exhausting Pumps to suck the Air out, and thus produce an artificial current of Air throughout the workings for the purpose of diluting and expelling the Gas that has been allowed to issue into the workings. These plans theoretically may be very true; but it is to be observed, that the current of Air must be constantly maintained, and in the practical application, the Engine that works these Pumps or other Mechanical méans may get out of order; a rod may break, a valve may obstinately stick open when it ought to shut, and then what becomes of the lives of those individuals depending upon the due action of every part of the Machine. This fatal objection attaches to all mechanical plans for ventilation; and indeed to all *artificial* modes, where the *power* of Ventilation is not *self-acting*, but requires the constant *action of Machinery* or the constant *aid of Men;* even including the ordinary plan of rarefaction of the air by a separate fire, which may be *out* when it ought to be *in;* and ought not to be relied upon as the *sole protector*, though it will be in some circumstances an useful *auxiliary*.

Therefore we should avail ourselves of the natural powers that are at our command as far as possible; as in this instance the extreme levity or natural ascensive power of the Gas from which we wish to rid the Mines, supplies us to a considerable extent with

the remedy required. But cases may arise where other auxiliaries may be temporarily required from accidental displacements of the level of the mine; (though in the Author's opinion these cases may be reduced to a few, if the Mines are opened out and worked upon a proper system, as will be further noticed in this paper;) and under these circumstances, it may be necessary to employ Heat to rarefy the Upcast current of Air, to make it specifically lighter than the Downcast, or Mechanical means to force Air in or to extract Air from the mines may be required. Where Artificial Heat is made use of, a Steam-jet from the boiler of the winding engine is the most secure method, because the steam being supplied from the boiler of the winding engine, it is clear that the steam is always at command, whilst the pit is at work. If Mechanical means should become necessary, Mr. Struvè's exhausting cylinders supply the most powerful and effective apparatus that has fallen under the Author's notice.

The object of the present paper is to show that there is a *constant self-acting* power available, which experience has shown will afford the desired protection in ordinary temperatures, in the majority of cases; because the Carburetted Hydrogen of the Mines being less than half the weight of Common Air, (it has an equal ascending power to Common Air heated to 512 degrees, being of the same specific gravity,) will always rise to the highest parts of the Mine, and would escape with great velocity, if permitted to do so, forming in the aggregate a very large ascending power, as exemplified in the balloon; but in the ordinary system of working this escape is unprovided for, indeed absolutely prevented.

The ordinary system adopted in the Collieries of this district is shown in Plates 24 and 25; two shafts are sunk near together, about 7 to 7½ feet diameter, each to the bottom of the Coal, say about 180 yards depth; the two shafts commencing at the same level and terminating at the same level. One of these becomes the "Downcast pit," down which the Air descends, and the other the "Upcast pit," up which the Air ascends, when a communication is made between them at the bottom; but the only determining causes for the motion of the Air being accidental, it is unknown before hand what

direction the current will take, and which will become the downcast pit. It is generally found that a current of Air does take place, (it may almost be said always takes place) without any other means being employed; but the determining power is so faint, that issuing from the upcast pit with such trifling velocity, it is liable to be deranged by the action of the wind or by atmospheric changes, and it sometimes happens that the Air becomes quiescent, or an unsteady column, alternately ascending and descending the same shaft; and then, in Miner's language, the Pits "fight," and the Air will neither ascend nor descend with regularity in *one* direction. But worst of all, the course of the Air will be sometimes inverted or "turned;" that which should be downcast pit becoming the upcast; and the mine then becomes exposed to the most fearful results, where the workings have been opened, by the Air being driven backwards along the Airhead into the reservoirs of Gas formed in the upper cavities of the workings, and issuing into the Gate-road charged with the Gas to the firing point, causing an explosion, of which many familiar instances might be adduced.

The danger of this change in the direction of the Air current is seriously increased by the *upcast* Pit being used as a *working* shaft. The upcast Pit, which is in fact the *main* Gas and Air way, and which ought always to be closed from the external air, and the ascending air current guarded from disturbance or commotion, to prevent the slightest *interruption* to the current of air upon which the lives of all depend, is kept in a state of constant agitation by the ascent and descent of the "skips" loaded with Coal, which nearly fill the shaft. To crown this, when every skip arrives at the top of the shaft, a carriage boarded over, called the "runner," is wheeled over the mouth of the pit whilst the Coal is landed, and then withdrawn to allow the skip to descend. It is obvious that the air, which should never be disturbed, is thus constantly liable to be in conflicting currents more or less, sometimes upwards and sometimes downwards, and whenever the Mouth of the Shaft is covered by the runner, the air is in a state of partial stagnation. But it sometimes occurs that the chain or tackle by which the skip is suspended *breaks* during the ascent in the upcast Shaft; the skip then drops down the shaft, drives the air before it with great velocity along the

Air-head, and forces the Gas out of the cavities into the Workings downwards upon the candles of the workmen; and this the Author has known to happen many times.

When the two Pits are sunk down through the stratum of Coal 30 feet in thickness, a "Gate-road" or Horse-way is next driven in the bottom of the Coal from 8 to 9 feet high, and about the same width, commencing from the bottom of the downcast pit.

At the same time (or rather before, as it should always precede the Gate-road) an Air-head is driven about the *middle* of the Coal, or 15 feet high from the "floor" or bottom of the Coal, commencing from the downcast pit. The Gate-road and Air-head are then driven in parallel lines at the same level upon which they commence, for the distance of 100 to 500 yards or more, according to the quantity of Coal intended to be cleared by the Pits.

A series of "Spouts" or openings are driven *upwards* from the Gate-road into the Air-head at intervals of each 10 or 15 yards, (as the Coal may give out more or less Gas,) which carry off the Gas, and produce a current of Air for the workmen, each spout being closed up when a new one is made in advance. The excavation of the whole thickness of the stratum of Coal 30 feet thick is then proceeded with, by opening right and left from the end of the Gate-road, and excavating a "side of work" which forms a square cavity, say about 90 yards long by 50 yards wide, or about an acre; the whole of the Coal being taken away as far as practicable, excepting the "Pillars" of Coal, generally 10 yards square, and 10 yards distance from each other, which are left to support the superincumbent strata.

The Air descending the downcast pit, and travelling along the Gate-road into the Workings, ascends to the Air-head, and traversing that, ascends the upcast pit, carrying with it the Gas and impure vapours, as far as such imperfect and interrupted means will effect, and delivering them into the open air.

By this plan, we may contrive, where this system is adopted, to ventilate the mine, though imperfectly, until the lower 15 feet of the Coal is excavated; but where the whole thickness of the Coal above the Air-head has been removed, by undergoing the Coal from the bottom, and dropping it down in large masses, the upper portion

of the cavity being above the level of the Air-head forms a reservoir for Gas, which gradually accumulates, and has no means of escape; a reservoir of the capacity of some hundred thousand of cubic feet, which may be wholly or in part occupied by Gas. An accidental change in the current of air, the direction becoming reversed as before observed, which does occasionally happen, (arising from many causes, such as mere changes in the atmosphere, as well as the cause mentioned before, of the breakage of the tackle, and sudden fall of the skip down the shaft,) would turn the course of the air along the Air-head into this reservoir of Gas, and from thence into the Gate-road; and then, if a portion of the air became charged with gas to the firing point, an explosion would inevitably ensue. After the Coal is extracted, a solid wall or "rib" of Coal, from 6 to 10 yards thick, which is commonly termed a "fire rib," is left all round the chamber, separating it from the next workings, and the entrance from the Gate-road is securely walled up to exclude the air, and prevent spontaneous combustion, which would otherwise in a short period take place. When an explosion occurs, it is generally followed by a second or more, as portions of the Gas become successively charged with the due proportions of Air; and the liability to these terrible explosions will always remain in mines thus worked, till by some efficient means the Gas can be allowed a continuous escape by its own levity, and a current of air for the necessary purposes of life and light can be ensured to move always in *one* direction, with *sufficient power* to overcome all extraneous disturbing forces, either of the wind or any atmospheric changes.

Plates 26 and 27 show the system adopted and carried into operation by the Author. One Pit only is sunk instead of two, and in the side of the shaft a smaller shaft is cut to form an "Air Chimney," and is afterwards separated from the main shaft; this Air Chimney circular, and may be made about 3 feet diameter inside, or more, as may be required. This is done simultaneously with the sinking of the shaft, and it very little impedes the rate of sinking, as an additional man has room to work in it, and he keeps pace with the sinkers of the shaft. This Air Chimney is bricked at the same time with the Shaft, the circular brickwork of each forming a parti-

tion of double thickness and secure strength, from the two arches abutting against each other.

This Air Chimney is carried from the top to the bottom of the Shaft and is sufficient to carry off all the Gas and such quantity of Air as may be required in the mine. The men carry always an abundant supply of air *with* them, and the efficiency of the Air Chimney is strikingly displayed in sinking the Shaft; when the ordinary pits are sunk, after a charge of Gunpowder has been fired in blasting such measures as require it, (and most of them do,) a considerable space of time elapses before the smoke is sufficiently dissipated to allow the sinkers to descend and renew their work; but when the Air Chimney is used the smoke is at once dispersed, and before a man can reach the bottom of the Shaft, it is carried away by the Air.

The Gate-road is driven from the Shaft at the bottom of the Coal as in the ordinary plan, but the Air head is driven from the Air Chimney within two feet of *the top of the Coal*, or higher if practicable, the vertical Air Chimney terminating at the level of the horizontal Air-head. The Gate-road and Air-head are carried forwards in a parallel direction to the extent of the work, as before described in the ordinary system; and " Spouts " or openings are driven upwards to connect them, at about every 15 yards, in the same manner as before described, every spout being bricked up close in succession, when a fresh one is made in advance, so as to make the current of Air traverse the whole extent of the Gate-road before it rises up to the Air-head and passes away to the Air Chimney. These spouts can only be driven perpendicularly *upwards* from the Gate-road to the Air-head, and each of them being about 18 feet long in the 30 feet Coal, a formidable practical difficulty was experienced by the Author in the King Swinford Pits, where the Coal being contiguous to a great fault, it abounded in Gas to so great a degree, that when a spout was carried up a very few feet, it became so filled with Gas that no man could work in it. But to show how small an aperture is necessary for the escape of the Gas in its undiluted state, this difficulty was overcome by boring upwards from the spout a hole four inches diameter into the Air-head; the Gas fled off instantly, followed by a stream of Air sufficient to ven-

tilate the Gate-road and to enable the men to work with Candles in the spout with perfect safety.

The excavation of the Coal is commenced in the same manner as in the ordinary system, by driving at right angles from the end of the Gate-road, to begin a "side of work," and the ventilation is carried on completely and continuously from the extremity of the working, whilst the whole of the Coal to the top is removed. The whole of the Gas is *constantly drained off* from the *upper surface* of the Coal, by the Air-head and the numerous spouts or cross drains, which remain all open to the Air-head by means of a small pipe-hole left in the stopping as they are successively stopped, and which constantly *drain* off the Gas most effectually, by piercing through and cutting the horizontal layers of Coal, and thus tapping the several strata at so many different points. The process resembles that of draining a bog of its water by cutting two main parallel drains, thus dividing the whole into a series of square portions; but the Gas will escape with a greater facility than water, and is carried off by its own levity, causing a rapid current in the Air-head without the assistance of an artificial current of Air, as fast as it is released by the removal of fresh masses of Coal, which is a circumstance giving all the necessary facility for rapidly draining the Coal. By this system the danger of any accumulation of a reservoir of Gas in the cavities of the upper part of the workings is effectually prevented.

That the Gas is lighter than the Air must have been known ever since mines have been worked; but, as far as the Author's knowledge extends, no other practical mode has ever either been adopted or recommended to effect the purpose of draining off the Gas. Boring holes from the surface through the Coal was one plan suggested; but independently of the utter inefficiency of the plan, the expense would be so enormous as to put that wholly out of the question; added to which, the holes would be in almost all instances filled up, either by earth falling into them, or by water lodging in them, which would render them useless.

Another plan which has been suggested, has been to drive an Air way or road all round the area of Coal which has to be got, in the same way as a fosse might be made round a fortified place; the Author

believes it is all but impossible to drive such an Air-way at all; but, even if it could be driven, it would be perfectly useless ; such an Air-way would not drain the Coal to 10 yards distance, and would leave the whole interior of the mine intended to be got charged with Gas in its original state ; and unless the whole of the horizontal veins of the Coal were cut through, from the top to the bottom of the Coal, the Gas would not be extracted from the Coal, even within that distance; consequently, this plan may be pronounced equally impracticable and useless ; for it cannot be too frequently impressed upon the attention, that Gas will not pass *vertically* through the Coal, but only from the *horizontal* layers or divisions.

A Plan was suggested by Mr. Ryan to drive a Gas drift along the cross or upper edge of the area of the body of coal intended to be worked, or encircling the coal in some cases, under the mistaken idea that the Gas, from a distance even of a mile or more, would rise to the highest point of the Mines, and the Coal be thus gradually drained. Laying aside the question of expense, which would be a sufficient objection, such a Gas Drift, even if it had intersected the Coal through the whole thickness, would have had no effect whatever; for nothing short of dividing the Coal into sections or squares of not more 15 yards thickness would be of the least service, and that must be done vertically and horizontally, for the first Slip or Black Face will intercept the release of the Gas, as any smooth face forms an impervious barrier to its passage.

In the ordinary system of ventilation, it is manifest that only a very slight determining power compels the Air to travel constantly in the same direction ; its current is at all times weak and insufficient, and liable to be deranged by the action of the wind or atmospheric changes, and it is under no *command* whatever. To ensure safety, a constant current of Air is indispensably necessary; it should be a current, too, maintained by natural causes, as far as possible, and never interrupted, for the reasons already assigned, and should be one that will not vary or fail.

To effect this, the *ascending* Column of Air must be rendered specifically lighter than the Air of the *descending* column, which cir-

culates through the workings, and this difference of specific gravity must be maintained constantly *free from disturbance* by accidental causes, and to such an extent as to produce under all circumstances a total amount of *propelling power* that is found sufficient for the complete ventilation of the mine. This is accomplished by conducting the whole of the Gas in a continuous *ascending column*, free from interruption or disturbance up the *separate Air Chimney ;* and this ascending power is further increased by erecting a " Ventilating Chimney," of a sufficient height on the surface of the ground, into the base of which the Air Chimney is continued, so as to form one uninterrupted Air-flue from the top of the Ventilating Chimney down to the Air-head in the seam of Coal. By this means a long experience has shown that a *constant draught* is established and secured, with the occasional aids of a small Furnace or Steam Jet, which is amply sufficient in all ordinary cases to defy wind and weather, and also to produce a current sufficiently strong that it may be split, and such portions withdrawn from the main stream of Air as may be found requisite to carry on the preparatory work to maintain the get of Coal.

The Air in the Gate-road and Workings is warmed above the temperature of the Air on the surface, in ordinary mean temperatures, by the heat of the earth, and is consequently rarified; this is aided much more than would be generally supposed by the heat proceeding from the numerous workmen, horses, and candles, employed in the mine, and the further current caused by the escape of the gases which are specifically lighter than the Air. The Air-head forming an uninterrupted and continuous passage into and through the Air Chimney from the Workings, and delivered into the Ventilating Chimney, and a draught is constantly maintained sufficient for all usual purposes. The weak power of draught that exists in the old system is materially diminished by the *upcast* shaft being of a larger size than the Air-head through which the air must pass, and open to the external Air, and thus cooled down below the temperature of the Air after it has travelled through the mine. The ascending current in consequence of the large area of the upcast shaft as compared with the Air-head is languid and slow, which is another decided objection: whereas, in the Author's judgment, the

ascending current should have *considerable velocity*, and much more important advantages arise from this cause than philosophers either account for or will admit.

Cases may occur in which it is desirable, for temporary purposes, to *increase the draught*, either when the external air is at a very high temperature or from other causes, and this at once obtained by adding a Furnace or a Steam-jet of any required power to the Ventilating Chimney; by means of a fire in this furnace any degree of rarefaction may be produced that is desired in the Ventilating Chimney, and it is recommended always to build one, where the Boiler Chimney cannot be used, that it may be used if it is wanted. In such cases, the flue of the furnace should be carried up perpendicularly for 30 or 40 feet against the side of the Ventilating Chimney, before it is opened into it; this precaution will render a deflagration of the gases passing up the Chimney impossible when the furnace is used. It is in most cases practicable to make use of the Chimney of the Winding Engine as a Ventilating Chimney by making it of sufficient dimensions, and dividing it into two equal parts, by a wall of about 30 feet high; this being always in a heated state, acts very powerfully and efficiently, one division ventilating the Pit and the other being appropriated to the fire of the boiler. This plan has been adopted by the Author at all his Collieries, as he has in all cases the Chimney of the Winding engine built of sufficient dimensions, and divided in the centre by a wall half brick thick. An additional means of increasing the draught when required, is also afforded by inserting a steam-jet from the boiler into the ventilating compartment of the Chimney, and where high pressure engines are employed for winding, the steam is discharged from the cylinder into the ventilating compartment for this purpose, producing a powerful draught as in the case of the locomotive engine. However as in case of repairs of the boiler and its brick-work, the ventilation *might* be for a short time *disturbed*, although no danger need be expected to arise; such is the great objection to any breach of the system, however slight, that the Author would think it prudent to erect a *separate* Ventilating Chimney to be kept in *reserve* with a furnace attached for important Pits, to be used when the Ventilation of the Boiler Chimney is thus suspended.

On some occasions, temporary departures from the *Rules* laid down may be *unavoidable;* but these cannot be termed *breaches of the system.* Slips up and down-casts, mucky or rotten coal, interpose obstacles which must be removed or provided for in the best manner that the skill and experience of the Mine Director can discover, for in such cases no rules or regulations can be insisted upon, except that of taking care to abridge any necessary departure from the system, and re-establish it as quickly as possible. It is by no means an unusual practice to depress the Air-head in parts, and then raise it again to its former level, under the erroneous idea that the gas will, like water, regain its level; but it will not, the Gas will not *descend,* and a serious interruption to the proper ventilation of the mine is interposed.

The principle of Ventilating Pits by an Air Chimney, used for *no other purpose* than the passage of the Gas and the current of Air from the Workings to the surface, has been adopted by the Author in a more or less perfect form for more than thirty years in working the Thick and Thin mines, and has been found to give a complete and absolute *command* over the ventilation of every part of the mines. It is only, however, within the last few years that he has had an opportuuity of carrying it through many extensive Pits systematically. In the whole of the Author's mines, this system of ventilation is now completely carried out; the Thick Coal is sometimes worked in one Pit, and in another Pit Brooch Coal, Heathen Coal, or the White Ironstone lying beneath the Coal, and sometimes the Thick Coal is worked in both; very little preparation is necessary for this change from one to the other, as the Air Chimney reaches to the lowest vein, and a stopping being put in at the level of the vein intended to be got, a supply of Air may be immediately procured at any required Level. The Thick Coal *abounded* in Gas in these Pits, but it is now so *drained* that all difficulties have disappeared; the use of the Safety Lamp has become a form rather than an essence; but it is never suffered to be neglected, as it tends to establish habits of care and circumspection in other cases.

A great improvement has resulted to the *health* and *comfort* of the workmen employed. The Air in these Pits is always free from

gas, and is ten degrees (Fahrenheit) cooler than the neighbouring Pits, worked on the ordinary system, owing to the regular supply of fresh Air. They have been frequently tried, and found to be 62 to 64 degrees in the Workings, whilst at the same time the Air in the Workings of Pits ventilated in the ordinary way, was found in many cases to be 72 to 74 degrees ; the former, the temperature of a comfortable sitting room, and the latter, that of a heated cotton mill.

A very great saving of expense from this system will be found also, not only in working the Thick Coal, but subsequently in getting the thinner veins of Coal and Ironstone. A very considerable amount of outlay, as well as frequently a great loss of time, is incurred in obtaining the necessary supplies of air for working the successive strata of a mine. Whereas the Air Chimney is accessible at any point in the Shaft, and the Shaft is *always* kept well aired, which is of importance, as it is often found convenient to suspend the workings of the Pit for a considerable time after the partial exhaustion of one of the strata, and before it may be desirable to commence the working of another. The Pits with the Air Chimney have been always found to be in a perfectly well aired state, and quite safe to descend and commence new operations in a day's notice, after the suspension of the workings for several years. A very considerable saving will be found to result from this circumstance before the whole of the strata are worked out, where the strata are numerous. It may be observed here that an Air Chimney may be very easily cut down any Shaft which has been sunk in the usual way ; the Author has cut one down a Shaft during the night, whilst the Pit still continued to draw coal during the day ; he executed one in a pit 140 yards deep in about a month, the pit continuing to draw coal during the day, whilst the air chimney was made in the night.

Where large quantities of coal are to be drawn a number of Shafts are necessary ; two of these may be sunk at the usual distance of 10 or 12 yards, near enough to be commanded by the same Winding Engine, but the Shafts having no communication with each other. But if the form of the mine makes it more convenient, they may be sunk singly in any required situation, because each separate Shaft will provide its *own Air*, and each Shaft will "get"

the separate section of mine appropriated to it; (by this means small detached portions of mine have been got to advantage, that would not have paid for the expense of two shafts.)

By this arrangement, a much smaller quantity of Air-heading is required to "get" the same area of Coal, and the process of complete Ventilation can be more easily carried out, as will be hereafter noticed; and although communications between different Shafts by the Gate-roads might be occasionally convenient, these communications may be under the care and sole control of the Mine Director, who may keep the doors locked, if advisable; the Ventilation is thus not materially disturbed.

In the different plans for Ventilating Mines, the merit appears to have been awarded to those more especially who have succeeded in *forcing*, by any means, either mechanical or by the use of powerful furnaces, the *largest possible quantity of Air* through the workings in a given time. The principle explained in the present paper is totally different and diametrically opposite, for it is grounded on draining the gas away from the coal *before* it is worked, and then getting the coal when it is thus drained, and carrying *no more* Air through the Mines than is required for light, life, and health, and it is founded on the old maxim that "prevention is better than cure."

It is perfectly true that if a Mine supplies 1000 cubic feet of Gas per minute, then, and in such case, 30,000 cubic feet of Air per minute must be passed through the workings in order to dilute it to the point of safety, and to make safe provision for the varying circumstances of change of atmosphere which may slacken or affect the ventilation; that is, if the Gas is allowed to *pass through* or into the Workings at all. But the principle advocated in the present paper is to *prevent* the Gas passing into or through the Workings, and to allow it to escape by proper passages made above the level where the Men work, and to allow it to *pass away* by its own levity, which it speedily and rapidly does, if proper outlets are provided for its escape in the highest part of the Mine. That is to say, supposing, as a general illustration, that 1000 cubic feet of Gas per minute is emitted by the Coal and *passed through the workings*,

35,000 cubic feet of Air per minute must by some means be forced to pass through the Mine; namely 30,000 feet to dilute the Gas and 5,000 feet to supply the workmen, horses, and candles in the workings; but if the whole of this 1,000 feet of Gas can be carried off by its own levity, and intercepted from passing *into the Workings*, then the Mine will be better and *more safely* ventilated by 5,000 feet of Air per minute than by 35,000 feet in the former case; or, if the whole of the Gas cannot be intercepted, then in such proportion as the volume of Gas can be intercepted and carried away. And supposing the opinion of the Author to be correct that the Gas can be carried away without passing into the workings, and that, therefore, a very greatly reduced quantity of Air is necessary in the Mine, it follows, that the Gas being of the same specific gravity as Atmospheric Air heated up to 512 degrees, that, when the Gas becomes diffused and united with the Air, the volume of Air and Gas so united, is of less specific gravity than the Air, and will maintain a *natural* Ventilation of considerable power. It may be observed, also, that very rapid currents of Air through the passages of a Mine, are always attended with great inconvenience to the workmen, and may be attended with great practical danger, from the circumstance that the union or perfect admixture of the Carburetted Hydrogen with Atmospheric Air, though very rapid, is not instantaneous: and when in a Mine not previously drained of its gas large quantities of the Gas suddenly escaping from powerful "blowers" are driven forwards by a current of Air moving seven to ten feet per second, it is very conceivable that they are not diffused at once, but carried, in some degree like a cloud of steam, forwards through the Mine, till diffusion has brought a portion to the "firing point," and then meeting with a light, or even driven (as they may be) through the wire of the safety lamp, will explode.

Many cases of explosion have occurred, where evidence has been given of the Mine being well aired, and the cause of the explosion has remained unexplained, and not even, with any reasonable probability conjectured; but the Author suggests that it may very possibly have arisen in some instances from this cause; and unless the rapid movement of the air can be proved to be indispensable, a slower rate of movement would be far preferable, both for convenience

and safety. And the Author is particularly desirous to impress upon the attention this circumstance, that if the Gas is carried off, and in consequence the Volume of Air necessary for the safe Ventilation of the Mine can be reduced as much as five-sevenths, or even three quarters of its Volume, that the Air-heads may be safely reduced in their dimensions in a proportionate degree, and yet remain equally effective; and as no Gas is mixed in the Air, the Workmen will be infinitely more secure. An objection that was made to the adoption of the system, was the possibility of some disturbance of the brickwork which separated the Air-Chimney from the main Shaft, either by a violent blow from the ascending skip, (which of course could not be the case with the guides, that are now generally used,) or by any accidental explosion that might take place in the Mine, which it was contended might force it outwards into the main Shaft. A mere inspection of the plan must convince any practical person that such an occurrence is impossible ; any force from without would be resisted by the convex surface of the Arch which encloses the small Shaft, as any operating from within would be as effectually resisted by the convex surface of the main Shaft. Not only did no such occurrence ever take place in the numerous pits where the plan has been used without guides, but even where the Air Chimney was cut square, possessing so much less resisting power; and they remain now perfect and uninjured after a lapse of more than thirty years.

Another objection was that the Air Chimney was not of sufficient dimensions to ventilate the Mine; (and this objection was urged and re-urged in the face of the fact, that the Author had expressly stated that cases might occur where even a seven-feet Air-shaft might be required and employed to drain very fiery mines.) The parties making this objection did not happen to recollect, that in fact this *Air-Chimney* was precisely of the same area as the *Air-head* which they themselves always employed to form the communication between the workings and the upcast Shaft. That in fact the Air-Chimney was neither more nor less than a continuation of the Air-head from the workings to the surface of the ground; consequently they fell into this glaring absurdity, that it was necessary to have an upcast shaft with an area equal to about 38 square feet to

form a communication between the external air and a downcast shaft containing an equal area of 38 square feet, whilst the Air-head, the only Channel which connected these two shafts, (with a length of perhaps 1000 yards) and through which the descending air was compelled to circulate before it arrived at the upcast Shaft contained an area of only 7 or 9 square feet. The effect of this was to diminish the velocity of the ascending column in the upcast shaft, to lose the increased temperature the Air-head acquired in passing through the mine and the great advantage of *equal* velocity in the ascending current, and by that means to materially reduce even the small ventilating power that had been obtained.

Another objection was, that in some of the thinner veins no upper Air-head could be driven at a sufficient height to allow the gas to escape by its own levity, or to prevent it from getting admission to the Workings. There may be exceptional cases—as, for example, if a mine can be supposed to lie upon a perfectly horizontal plane,—(but the Author never saw an instance of a mine to any considerable extent answering this description; in all mines he has ever seen, the Coal forms some angle to the horizon in some direction, and a very small angle will soon obtain a height of six or seven feet, which is quite sufficient for the present purpose,)—in that case the Air-head communicating to the upcast shaft may be made always to ascend to the higher part of the plane, which will be quite sufficient to keep the mine clear from gas, by allowing it to pass off by its own levity. But, even if such a case ever should occur, a remedy may often be obtained, an instance of which has lately occurred to the Author. A disturbance in the Thick Coal vein was found, breaking the Coal through and throwing it into a trough 15 yards below its level; of course if the Air-head had continued to follow the vein, it must have been depressed below its level, the whole thickness of the Coal, which would have formed a barrier against the passage of the gas, like an inverted syphon, which the gas would not have passed. The remedy adopted by the Author, was by commencing an Air-head from the Air-Chimney in another measure, the "Flying Red," that lay 20 yards above the Main Coal, and continuing it till it had passed over the depressed point; a communication was then formed to the upper side of this depressed part, which at once established a rising Air-head for the whole of the Coal on the farther side of the depression. This is mentioned

only as one instance to show that it does not necessarily follow that the principles here recommended may not be carried out, in case of meeting with the ordinary upcasts or downcasts which exist in most Mines.

It may be perceived that the plan of Ventilation here recommended is combined, in some measure, with the method of working the mines, and may be made more perfect and efficient by the adoption of a sound system. The common mode is that of working the mines in "panes," or "panels," leaving "pillars," or portions of Coal, to be extracted at a future period; but this is considered by the Author as not only highly objectionable as opposing great difficulties to the proper ventilation of the mine, but as compelling the Air to be carried through long and tortuous passages, and split into numerous currents, and thus reduced in its velocity to perhaps one foot per second, of which examples are given in the South Shields Report, and increasing the length of the Air-passage to the extent of 70 miles, and the air thus occupying 16 hours in traversing the mines from the downcast to the upcast Shaft.

The danger of this method must be sufficiently obvious, when it is seen that the Air must be forced through these various openings in the most crooked and winding channels, and its course compelled to pass along by artificial buildings, or "brattices," the the accidental destruction or failure of which may suspend the whole ventilation.

But the plan exhibited will show that, before any Coal is got from the mine in the method recommended by the Author, the roads are carried out to the extreme extent that the Coal is proposed to be worked, accompanied by their Air-heads; by this means the complete drainage of the gas from the mass of Coal proposed to be worked is effected, and these roads and their Air-heads are originally made at infinitely less expense, and are always in a safe and secure state, as the excavations commence at the outside of the Coal thus intended to be got; and that no brattices are necessary, as double doors may be used in any of those roads down which the Air is intended to circulate, either to regulate the quantity, or prevent its passage; and the current of Air may be always brought to act directly upon the working face of the Coal.

It may be objected that these pillars must be left for a support

owing to the nature of the roof of the mine; but this the Author has never yet seen, and is disposed to think that it never can happen. He is getting veins of Coal of thirty feet in thickness, (in two successive workings of 15 feet each,) also veins of six feet, four feet, and three feet thicknesses; the roofs of these various coals differ in their tenacity, and some of them are extremely tender, and yet the *whole** of the Coal is extracted from these veins, both the thickest and the thinest, both large and small Coal, with the greatest facility and safety; and if the Author was called upon to express a preference of any, he would prefer a tender roof to one formed of rock.

The dangers obviated by this mode of working are doubly important; the roof gradually descends as the mine is excavated; all dangers are left behind, and the roof is consolidated into a compact mass by the weight of the superincumbent strata, consequently no "goaf," or hollow, is ever formed, and no lodgement of gas can take place. Secondly, no large or small coal being left behind, the heating of the goaf, or the spontaneous combustion to which all mines are liable where small coal or slack is left, can never take place.

The Author, as observed at the commencement of this paper, wishes to avoid entering upon any remarks that may appear to censure any of the systems of getting mines different from that practised by himself. He does not wish dogmatically to assert that such systems may not be necessary in some cases, although it is not apparent to him why they ever can be necessary. Men of great science and ability, he is willing to believe, may have good and valid reasons for the adoption of the plans they pursue in particular cases;

* *Note.*—The extraction of the *whole* of the 30 feet coal was first accomplished in the collieries of James Foster, Esq., on the suggestion of George Jones, Esq., some years before any other person attempted it; it is, indeed, only carried out successfully at present by Mr. Foster and the Author. The Author is happy in having this opportunity of giving his testimony to the fact, and also to the credit justly due to Mr. Jones, for his bold and correct conception; and to Mr. Foster, for his sagacity and energy in carrying it out. The Author has shown (what might have been doubted) that this is done with perfect success, and that it is quite suitable to his principles of ventilation, and, indeed, is admirably efficient in *practice*, as regards the drainage of the gas from the coal.

but others may imitate their system where the same reasons that may be urged in those cases do not apply. But, as the Author is prepared to show that they offer very great impediments to a sound system of Ventilation; that in case of accident they are attended with the most awful and distressing results; it would be inexcusable in him not to make some remarks as to their disadvantages, for the purpose of pointing out to the observation and attention of those engaged in mines the propriety and necessity of making these modes of working mines as *few* and *exceptional* as possible.

He has already observed that, in the mode of working mines in Panes and Pillars, where a part of the Coal is of course left, and eventually lost, the difficulty of obtaining safe ventilation renders its accomplishment nearly impossible; and upon this point he will only notice further the deplorable consequences that follow when an accidental explosion takes place. At Newcastle-on-Tyne, the brattices being all blown down by an explosion, and the workings all filled with carbonic acid gas, and no means existing of quickly restoring the ventilation (which arises from the system employed, as at the Felling Colliery and many other similar cases,) the Pits and Workings could not be entered, nor the bodies of the men recovered for weeks, nay, even months. Every man in the mine, though out of the reach of the explosion, necessarily lost his life by the *after-damp.* A very recent case in Scotland, at Nitshill, where sixty-one lives were lost, is a striking example; although this Pit had a good and distinct Upcast Shaft, the Brattices were destroyed, the Air of course proceeded along the shortest and most direct road from the Downcast to the Upcast Shaft, and all the men who had been supplied with Air by the diversion of the currents, depending entirely upon Brattices which were destroyed by the explosion, miserably perished, and the whole of the bodies could not be recovered in a week's time.

The Author will next allude to the sinking of Shafts of large diameter divided by Brattices, and of such large dimensions as to allow one side of the brattice to form the Downcast, and the other the Upcast Shaft. A similar result follows in the event of an explosion to the recent case in Scotland mentioned above; a part

of the brattice (probably at a considerable depth) is ruptured, and no current of Air can be procured to admit of its repair, except by means which involve loss of much time and expense. In the meantime, all those who may have been in the pit, at the time of the explosion, cannot be approached. The Author presumes that some idea of economy introduced this system; but he is satisfied that upon this point an erroneous impression has prevailed. The expense of sinking these single divided shafts, of the usual diameter of 15 or 16 feet, is so very great, that it has led to the practice of working very extensive areas of Coal by means of a single Shaft, and this practice has further led to the different scientific contrivances for impelling the air over these immense areas, by which the ventilation of the works is rendered so much more difficult and uncertain.

Taking, for example, a Pit of this description, of 15 feet diameter, by which is worked an area of 200 acres, (and instances might be adduced where four, five, and six times that quantity has been thus worked,) it is self-evident that the ventilation of a Coal Mine of this description, where the air passages have been extended to the length of 70 miles, must be attended with very great danger and vast expense.

Now the Author states as his opinion, and thinks he should have no difficulty in proving it correct, that four shafts might have been sunk on this Area of 200 Acres, 7½ feet diameter each, in proper positions with their Air Chimneys, for considerably (he dare not venture to say how much) less money than the one Shaft cost; and if this can be established, it follows that the 200 Acres being divided into Sections of 50 Acres each, the expense of the underground work would have been most materially diminished, and that the ventilation might have been effected with much greater ease and security in separate sections of 50 Acres each, and the power of raising Coal doubled, as there would be always two ascending and two descending corves, instead of one.

It may be alleged, that these larger Shafts are sunk with more facility, in consequence of the nature of the strata through which the pits are to be sunk, or the occurrence of quick or running sands of great thickness; but it is under these very circumstances that the facility and

saving of expense in sinking the smaller shafts is most strikingly manifested. As an example, we will take one of the most formidable difficulties, that of sinking through a great thickness of running sand. Now, in the sinking of the smaller shaft, entire cylinders or tubs of cast iron, descending by their own weight, may be used, excluding the sand as they descend; and, provided it is previously ascertained how thick the sand may be expected to be, sand of any depth, even 100 yards may be sunk through, by putting in the first tub of a size sufficiently large, so that when stopped, as it probably will be in 10 or 12 yards of its descent, by the friction of the sand, a second may be sunk within it, and so others in succession, (like the inverted tube of a telescope,) till the sand is penetrated to the sound measures. (See Fig. 3, Plate 24.) A running sand mixed with water was sunk through by the Author's advice, more than 20 years ago, by adopting this principle, in a shaft of 7½ feet diameter, and although the sand was between 35 and 40 yards in thickness, and of so fine and minute a character that, when dried, a great part would run through an ordinary hour-glass. Now, the Author cannot see how, in a shaft 15 or 16 feet in diameter, entire cylinders can be used, certainly not without enormous expense, and if they are to be joined in parts, (which must be done down in the pit) the expense and difficulty attending in that case the removal, and supporting of the ground until the cylinder is completed, must be enormous, which those engaged in such works must know well by bitter experience.

Now, with regard to the Ventilation, which is more immediately the object of the Author in introducing these remarks, it is obvious that, by sinking four shafts in the proper positions, this area of 200 Acres, is divided into four sections of 50 Acres each, and thus by shortening the Air passages, and dividing the portion of the gas furnished by the mines into four parts, and having the Coal drained by four distinct and separate channels, the ventilation may be safely effected with comparative ease and much greater safety.

Now, to sum up the conditions and principles to carry out the Author's plan effectually, he would state—

1st. That the Air-head should always open into the highest (practicable) part of the mines.

2nd. The Air-head (or what may be properly called the Gas-heads)

by which is meant the *horizontal* Air or Gas passage, shall always be in continuous communication from the Workings to a vertical Air-Chimney or separate Shaft, of 3, 4, 5, or more feet diameter, whichever shall be required, but always of sufficient dimensions to carry off the Gas and Air from the Workings.

3rd. That the Air-head, or Gas-head, shall not in any part of its course be depressed below the level of its opening into the Workings.

4th. That the Air-Chimney, (of such dimensions as the mine requires,) by which is meant the *vertical* air or gas passage, shall never be used for any other purpose than the passage of the current of the Gas and Air from the Workings to the surface, and that it shall be closed from the external Air till it arrives at its point of exit.

5th. That the vertical Air-Chimney should be closed at the top, and separated from the Shaft, and should then be connected to the Ventilating Chimney, or the Chimney connected by an horizontal flue with the boiler, so that the current of air may not at any time be disturbed or interrupted.

6th. That the Gate-roads should always be driven to the extreme point to which the Workings of the Coal are intended to be extended; that the Coal may previously be drained of its gas before any Coal is gotten, by which means the Gate or Horse-roads, and the Air or Gas-head, may originally be made, and afterwards be maintained, at considerably less expense in a safe and secure state, and the Gases be gradually drained off, before it is necessary to get the Coal.

As the object of this Paper, as first stated, is for the purpose of expounding the principles which the Author considers proper for the ventilation of Mines, it would be impossible, in the limits to which such a Paper must be confined, to enter into those details which might otherwise serve to make the subject much clearer than the Author is here able to do. It will be here impossible to enter into those particulars which would be necessary to explain the different methods that may be adopted to carry out these principles under the various circumstances of slips, upthrows, or downthrows, or those changes which present themselves in every considerable area of Coal. The Author must, therefore, confine himself to the statement that the cases are exceptional rather than general, in which there can be any insurmountable difficulty in providing the remedy for accidental derangements of this description,

without interfering materially with the principles recommended; that is to say, provided competent knowledge of the dip, and the position, and lay of the strata, is previously obtained by boring, or other means.

The Author once more wishes to observe, that he has no desire to enter into the disputable question of the proper method of working the mines in other districts of which he has not had personal experience; he is prepared to believe that good reasons may exist why men of science and talent have deemed the systems they have adopted to be those most suitable for getting the coal advantageously in the districts where these are employed. The remarks he has, therefore, ventured to make upon them are strictly limited to the results of his own experience, and only in as far as they interfere with, or form an impediment to the ventilation of the mines, and in those cases where the nature of the operations appears precisely similar, and are conducted for the same purpose, and he would not have alluded to them at all except that they are intimately connected with effecting that object of draining the gas and ventilating the mines as it appears to him in the most secure and effectual manner, with an important saving of eventual expense But the Author has arrived at the fullest conviction, in his own mind, that no plan of Ventilation can be safely carried out, unless more numerous shafts are sunk and smaller areas of coal are worked by them; and he is likewise convinced that that system will be found to embrace every consideration both as regards security and economy. The necessity of freeing the mines from *water* is recognised by every one; for it is imperative that proper provision be made for this purpose, because the mines *cannot* be worked at all until the drainage is effected; can any good reason, then, be assigned why no provision should be made for draining the coal from the *gas* when it can be so easily effected, and also, when that insidious enemy inflicts upon the mine owner, if it is retained, a much greater pecuniary loss eventually, and also what is of still greater importance, the loss of life to those meritorious and industrious men, who have a right to demand at our hands every security that can be afforded them.

Mr. Clift inquired whether, in a colliery of considerable extent, Mr. Gibbons would always sink the shaft at the extreme outside, in the highest point of the strata, for draining off the gas, or in the centre of the area, so as to have the work lying all round the shaft; and whether, in a large work, the air-head would not in some part have to descend towards the shaft.

Mr. Gibbons replied, that he would always sink the shaft at the extremity of the work, at the highest point of the coal strata, so as to drain off the gas from the whole of the coal; and he drove the air-heads, always ascending, towards the shaft, intersecting the coal strata every fifteen yards with vertical passages, through which the gas was constantly drained off into the air-heads.

Mr. Cowper wished to know if the shaft was sunk at the highest point of the strata, how the water was carried off?

Mr. Gibbons explained, that where it was required, he sunk a water-pit for the drainage at the lowest point, so as to drain the *water* from the *lowest* point of the strata, and the *gas* from the *highest*. He considered that 5000 cubic feet of air per minute were more than sufficient for any area of colliery that ought to be worked by one pit, provided the gas was previously drained from the coal in the manner he had described.

Mr. Shipton supposed that the nearer the ventilating chimney was to the pit's mouth, or the shorter the horizontal airway was, the greater would be the ventilating power.

Mr. Gibbons said he found that made little difference, the air-chimney being simply a continuation of the air-head, which was already horizontal in the workings, and the distance to the ventilating chimney being, in any case, quite insignificant in comparison to the length of the air-head.

The Chairman wished to understand how Mr. Gibbons was able to take out the whole of the pillars, as stated in his paper, so as to remove the whole of the coal.

Mr. Gibbons explained, that he began in the middle of the

thickness of coal, and worked the upper half first, commencing at one extreme side of the work, and driving a series of parallel roads about thirty yards apart, through the whole extent to the opposite side of the area of coal to be got; and he then worked backwards from the extremity, excavating the whole of the upper thickness of fifteen feet of the coal, and taking advantage of the superincumbent weight of the roof to bring down the coal; the the roof continued gradually creeping down, following the work, and filling up the excavated space that was left behind. The upper half of the coal was all got out by these means, and the roof all settled down filling up the space. He then proceeded to work the lower half in a similar manner, by driving a fresh series of parallel roads at the bottom of the coal, commencing at the same line as that from which the upper coal had been worked. The roof was found to be settled down after the fall, so as to form a new roof to the lower workings, quite firm and sound enough for the purpose; the first air-heads fell in gradually with the progress of the first excavation, being no longer required; but the communication with the air-chimney at the commencement of the work remained undisturbed, and the roof was left so porous after the fall, that the gas was constantly flowing off into the air-chimney from the lower coal workings, as readily as water filtrates through a bed of sand. By this mode of working, a very large quantity of coal per day could be got at one pit; it was only limited, indeed, by the winding power available, as the face of the work could be extended at pleasure.

Mr. Slate presumed, from Mr. Gibbons' paper, that the proportion of slack obtained was less, and the coal more, than usually obtained in the Staffordshire pits.

Mr. Gibbons said he did not obtain any more slack per acre, but a much greater quantity of coal By the old system, they got about one-third, and left two-thirds of the coal, but now none was left.

Professor Hodgkinson remarked, that there were, no doubt, great difficulties in effectually securing the object discussed in the

able paper read by Mr. Gibbons. When so great an amount of matter was excavated from the bottom, there must be proportionately great settlement in the ground above. In the neighbourhood of Northwich, Cheshire, the brine melted the pillars that were left in the salt mines, and sinking was constantly going forward; and when the pillars were wasted by time the whole ground settled down together.

Mr. ADAMS inquired where a coal mine was situated in a deep valley, how Mr. Gibbons would place the pit in such a case? Mr. Gibbons replied, that he would drain off the water downwards and sink a shaft at the upper level of the strata to drain off the gas.

The CHAIRMAN said there could but be one opinion upon the able manner in which Mr. Gibbons had brought the subject of coal-mine ventilation under their consideration. Of late years, the many fearful and frightful accidents which had occurred, owing to the accumulation of gas in coal mines, had rendered the question one of the highest importance, and any person who could suggest a remedy for an evil so disastrous in its consequence, would prove himself the friend of humanity. Proper ventilation appeared to be the only remedy, and he hoped the excellent paper that had been read would receive, not only from the members of the Institution, but from the public generally, that attention which it so justly merited. He moved a vote of thanks to Mr. Gibbons, which was passed, and Mr. GIBBONS expressed his willingness at all times to afford any explanation in his power upon the subject.

The following paper, by Mr. Joseph Beasley, of Smethwick, was then read:—

ON A NEW MACHINE FOR BLOOMING IRON.

The purpose of this Machine, which has been invented and patented by Mr. Jeremiah Brown, is to perform the process of Blooming the Iron from the Puddling furnace, which is usually done by Hammering, and in some instances by Squeezing; the

object being to squeeze out the cinder from the puddled ball, and to compress the iron into a form ready for rolling into a bar, which is done at the same heat.

The Machine is shown in Plates 28 and 29, and consists of three large eccentric Rolls A B C, placed horizontally in the strong holsters D D, the centres of the rolls being arranged in a triangular position, and the bottom roll C nearly central between the two top rolls A B. These rolls all rotate in the *same direction* as shown by the arrows, and are driven by a centre pinion E, working into three pinions of equal size F F F, fixed on the roll spindles; in the present machine the driving power is applied direct to the bottom roll by means of the large wheel G, for the convenience of carrying the main shaft under the floor—but it could be applied to the centre pinion, if preferred. The rolls are cast solid with their journals like ordinary rolls, and are driven in the usual manner by coupling boxes and spindles H H.

The roll-faces are 16 inches long, and the bottom roll has strong flanges at each end, 8 inches deep, between which the two upper rolls work; the object of these flanges is to upset or compress the ends of the bloom, as the iron in the operation is elongated, and the ends are forced against the flanges, which makes them square and sound, as shown by the specimen of a bloom exhibited to the meeting. The top roll A has a large hollow in which the puddled ball I, is placed by the puddler; and this roll carries the ball round, and drops it into the space between the three rolls, as shown in Fig. 2, this space being at that moment at its largest capacity. The three projecting points K K K, of the rolls immediately impinge upon the ball, and compress it forcibly on the three sides, and giving a rotating motion to the ball at the same time, they have a very powerful kneading action upon the iron, squeezing out the cinder very effectually, which flows freely away down each side of the bottom roll. The space between the rolls gradually contracts, from the eccentric or spiral form of the rolls, thereby maintaining an increasing compression on the iron on all sides and the ends, until it is liberated by the points L L L, simultaneously passing the bloom M, which falls down in the direction of the arrow, and is discharged from the machine at the same moment that another ball is dropped

in at the top of the machine. The projecting teeth on the surface of the rolls assist this action, by seizing hold of the iron and kneading into it as it rotates; and these teeth gradually diminish in projection, the last portion of each roll being plain, and the bloom is consequently turned out in a smooth compact form, as shown by the specimen exhibited. The space between the flanges of the bottom roll is widened for a short distance beyond the point L, for the purpose of allowing the bloom to drop out readily, and admitting the fresh ball.

A provision is made to prevent risk of breaking the rolls by any unusual size of ball being put in, by means of the two large triple-threaded screws N N, which bear upon the journals of one of the top rolls B; a small pinion on the head of each of these screws works into a large pinion fixed between them, which has a horizontal lever fixed to it, carrying a balance weight O at the end; this weight causes a constant equal pressure of the roll, and in the case of any ball of extra size being put into the machine, the screws yield by turning back and lifting the weight to the extent that may be required, so that a large ball will be worked with the same pressure and in the same effective manner as the smaller sizes. A continual supply of water is run on to all the journals throughout the machine, which prevents any possibility of the journals becoming hot, even when the machine is in constant work.

The advantages derived from this machine, are—

1st. The *saving of time* effected in the operation, as the machine makes five revolutions per minute, and turns out five blooms in that time, and consequently each bloom is only 12 seconds, instead of from 60 to 80 seconds, the time required in the usual process of hammering, being only about one-fifth or one-sixth of the time; the iron from the machine is therefore passed through the bar rolls at considerably greater heat than that from the hammer, and is consequently softer and better worked in that process.

2nd. The *saving of expense in manufacture*, as the machine is self-acting, and requires no men to attend the working; whereas, the hammer requires an experienced hammer-man in all instances, and sometimes two, depending on the number of furnaces the hammer has to work for, and these men are entirely dispensed with by the

machine being self-acting. An endless chain is also being added to the machine, working in an inclined direction from the lower side of the bottom roll, for the purpose of catching the bloom as it falls from the machine, and carrying it up direct to the bar rolls without any manual labour. In consequence of the machine turning out five or six blooms in the same time that one bloom is completed by the hammer, it is capable of working for a much larger number of furnaces, indeed for as many furnaces as can be placed within a convenient distance for working. Another important advantage from this circumstance is, that the puddlers are never liable to be kept waiting for their turns, as is often the case where one hammer works for more than 8 or 10 furnaces; on the contrary, with the machine, the greatest number of furnaces that can be arranged to be worked by one machine, will not be sufficient to employ it on the average more than one-quarter of its time, and consequently a very great margin is afforded for meeting the unavoidable irregularities in the supply of the balls from the several puddlers, which prevents the waste of iron, and deterioration in its quality that is caused when the puddler has to keep the iron back in the furnace waiting for his turn with the hammer.

3rd. The *saving of expense in tools*, which is very heavy where hammers are used; the hot iron being five or six times longer in contact with the hammer and anvil than with the machine, and the hot cinder out of the iron lying upon the anvil, instead of falling off constantly as it does in the machine; also the impossibility of applying a constant stream of cold water to the hammer as is done in the machine, cause the hammer and anvil to get so very hot, where a number of furnaces are working, that they wear out very rapidly sometimes lasting only a week, and are always liable to break, as also is the helve. The loss of time in replacing a hammer or anvil, when it breaks, or fails during the working, is at all times attended with loss in the quantity and quality of the iron, from being kept back in the furnace after it is ready until the tools are replaced; and when the helve breaks, the stoppage becomes a serious evil. The expense of keeping the machine in repair cannot be ascertained at present from actual experience, as the present machine at the Author's works is the only one that has yet been in regular opera-

tion for any length of time, and that only for the last four months; this machine is standing the work quite satisfactorily, and the only expense incurred since starting has been from an accidental breaking of one of the couplings soon after starting, through a defect of manufacture. An effective provision is made to prevent risk of breakage in the machine, by the driving clutch being made proportionately very light, so as to give way before any other part can be injured, and this can be replaced in five minutes at any time, if broken. The annual extra expense in repairs, and extra power with a pair of hammers to do the same work, would probably amount to as much as the total first cost of the machine.

4th. The *saving of power* with the machine, as the power is only exerted during one-fifth of the time required by the hammer, and during the greater portion of that time the power required in the machine is comparatively small, from the very soft and loose state of the ball, and the full power is not exerted until the revolution is nearly completed; whereas with the hammer the power absorbed is the same throughout the whole of the operation, as the same mass of the helve is lifted at each stroke of the hammer. Also less power is required in rolling the iron from the machine, in consequence of its greater heat.

5th. *Improvement in the quality of the iron*, in consequence of the cinder being more thoroughly squeezed out of the iron, from the enormous pressure to which it is subjected, and from the powerful kneading action of the rolls throughout the revolution of the machine whilst the iron is in a welding state, which unites the grain of the iron more effectually than can be done by the hammer. This action of the machine is *constantly* going on upon the iron, but in the other case the *greater portion* of the time is *wasted* in the lift and fall of the hammer, and this time is of great importance, as the hotter and more fluid the cinder is, the more completely can it be squeezed out from the body of the iron. The action of the machine is clearly shown by the accompanying Sectional Model, and it will be seen that the Ball is made to take a somewhat triangular form, by the pressure of the three rolls, and that every particle of the iron in its turn is by the revolution of the ball subjected to the kneading action of the rolls, and is thereby first

pressed in towards the centre of the mass, and again squeezed outwards by the pressure that other particles are subjected to, thus giving great facility for the escape of the cinder from every part of the ball, and forcing it out in a more effective manner than the ordinary process of working a four-sided bloom under the hammer.

There have been other machines invented on different principles, for the purpose of blooming iron by a process of *squeezing* instead of *hammering*, but the present machine is considered to possess important features of superiority, that enable it to surpass the hammer in the quality of iron produced, on account of the above-described action, which is peculiar to this machine; the certainty of the cinder constantly flowing freely away from the iron without risk of getting it lapped up in the bloom, and the perfectly uniform process that every bloom is subjected to, whilst the quality of the iron worked by the hammer depends entirely on the amount of labour and care bestowed upon it by the hammer-man.

Mr. Beasley exhibited a working model of the machine, and various specimens of iron rolled from similar blooms made by the machine and by the hammer from the same heat of the puddling furnace, to show the superiority of quality and greater purity from cinder in the iron made by the machine. Also specimens of a bloom from the machine and from the hammer, with one from the machine cut through the centre cold, to show the soundness of the iron.

Mr. Cowper showed a sectional model, full-sized, illustrating the kneading action upon the iron of the three spiral rolls, by the change that took place during revolution, in the position of the different points of a circular flexible hoop representing the ball of iron, which was compressed into the triangular space between the three rolls. He thought that, supposing the puddled ball could be taken hold of by the hand, and squeezed like a wet sponge, that would be the most efficient way of separating the cin-

der; and the action of the machine resembled this process, by kneading the ball between the three revolving surfaces; but the hammer performed the operation by hammering all round the ball on each side in succession. If the iron was tender, by rolling it between two surfaces, as in the other squeezers, it was torn open, but in this machine, with the three rolls, the iron is more supported, and is subjected to enormous pressure, and the cinder is more effectually squeezed out from the body of the iron.

Mr. GIBBONS observed he had seen the machine in operation at Mr. Beasley's works, and saw many blooms made by it, and all equal to the sample exhibited; he should say that the specimens of iron produced were fair specimens of the iron made; and his impression was that he never saw iron turned out more perfectly. The operation of the machine was very satisfactory; and it was important for the blooms to be all worked in a uniform manner, and made of even surface.

Mr. SIEMENS said he had tried an experiment to ascertain the comparative power required to work the machine and the ordinary hammer, by taking the indicator diagrams exhibited to the meeting, of the power of the engine when working without any load, and then the power when driving the machine alone, and when driving the hammer alone; the indicator diagrams were taken at various periods of the revolution of the machine, to ascertain the average power, as the power exerted at the commencement of the revolution appeared to be very small, and it was mainly concentrated at the last portion. The average power of the engine was increased about 4 horse power whilst the machine was working, and about 6 horse power by the hammer; but as the former power was in action for only 12 seconds in the operation of blooming, and the latter was 60 to 80 seconds in action, the total comparative power in the two cases would be as 48 (4×12) to 420, (6×70,) or as 1 to 9, showing the power absorbed by the hammer to be nine times as great as that by the machine. This, however, might require some correction, on account of the momentum of the engine fly-wheel, from some

power being given out at the moment by its velocity being retarded; he could not detect any loss of velocity in the present case, but a more accurate measure might be obtained of any differential velocity, and he hoped to have an opportunity of making a more complete trial of the comparative power of the machine and the hammer.

The CHAIRMAN inquired whether there was not danger that the machine would lap up more cinder in the iron than was usually the case by the common process of hammering.

Mr. BEASLEY said there was not any danger of it, and he considered it was impossible, from the action of the machine, that any cinder could be lapped up in the iron, as there was no possibility of a portion of the iron getting lapped over in the process and enclosing some of the cinder in a pocket or hollow, which was, however, the case occasionally with the hammer.

Mr. WALKER remarked, that there were traces of cinder in the specimens of iron from the machine, and he thought there must be some portions of cinder lapped up in the process. He did not think the machine would be so effective as the hammer in extracting the cinder from the ball.

Mr. COWPER said he had carefully observed the working of the machine, and considered its action was very perfect. The iron was subject to an enormous pressure, and he was decidedly of opinion that no cinder was lapped up in it. He did not mean to say that the machine produced better iron than the hammer but it was at least quite as good.

Mr. R. WILLIAMS observed, that if iron was imperfectly puddled, the hammer would knock it to pieces, and show the defect in the quality of the iron; but he thought the machine would roll the iron all up, whether good or bad. He was of opinion that, from the rolling action of the machine, the cinder would be lapped up in the iron.

Mr. BEASLEY said, it was found that, if the iron was not properly worked, or was "green" iron, it was shown at once by the machine tearing it to pieces, although in other squeezers it might still be wrapped up into a ball.

Mr. R. WILLIAMS considered the cost of the machine, and expense of keeping it in repair, would be an important consideration, and whether it would not be liable to accident and stoppage, from its complication compared to the hammer. He thought the different sizes of balls would not be equally well worked, as they wore with the hammer.

Mr. BEASLEY replied, that the machinery was precisely similar and not more complicated than the ordinary rolls, and no more liable to go wrong. This machine had been working four months without accident, except one which was from an accidental defect in the original make; and he considered it was decidedly less liable to stoppage and delay than the hammer. It was not intended to do away with the hammer altogether, but when larger sizes of iron were required, larger machines might be constructed for such a purpose. The machine was suitable for all the various sizes of iron in ordinary work by using the regulating screw.

Mr. SIEMENS thought the machine would work and last well, from the small power required to keep it in operation.

Mr. SLATE observed, that the machine possessed an advantage in being driven without the heavy cams and driving power required for the hammer.

Mr. WALKER thought the hammer was the best test of the quality of iron.

Mr. BEASLEY said he had never seen a bloom from the hammer perfectly free from cinder in the regular work, and those produced by the machine were decidedly more free from cinder than those produced by the hammer, and they never had any hollow in the body of the iron.

Mr. R. WILLIAMS remarked, that rolled iron was generally considered inferior to hammered.

Mr. BEASLEY replied, that the process performed by the machine was very different to that of rolling, from the action of the three surfaces; he referred to the samples exhibited to show the superior quality of the iron produced.

Mr. SLATE observed, that such specimens were not a true test; it depended greatly upon how they were broken.

Professor HOGKINSON said he had better acquaintance with the strength of iron than the process of manufacture; he had at first rather strong prejudices against the machine; he did not think it was exactly the right mode in which to get rid of the cinder, and it appeared to him likely to lap up some of the cinder; but he thought the objections he at first entertained were considerably lessened; the samples of iron from the machine, he must say, looked remarkably well.

MR. COWPER said he was, at first, much prejudiced against the machine; but his opinion was greatly changed since he had examined it in operation.

The CHAIRMAN observed, that the merit of the machine depended upon the relative quality of the iron produced, and there appeared a difference of opinion upon that subject. It was desirable that this point, as well as the cost of the different processes, should be ascertained, and laid before the Institution; and he, therefore, suggested that the inquiry and experiments should be further pursued, and the results reported to a future meeting.

A vote of thanks was passed to Mr. Beasley for his communication, and the discussion was adjourned to the next meeting.

The CHAIRMAN announced that the Ballot Lists had been opened, and the following new Members were duly elected:—

MEMBERS:

MR. JOSEPH BEASLEY, Smethwick,
MR. JOSHUA HORTON, Smethwick,
MR. JOHN STEWART, London.

The CHAIRMAN remarked that the subscription towards the erection of a monument to the memory of their late President, Mr. George Stephenson, was progressing favourably, and the Committee hoped shortly to be enabled to announce the nature of the memorial intended.

The Meeting then terminated, and the Members adjourned to the Library of the Institution, where coffee was provided.

BIRMINGHAM: PRINTED AT M. BILLING'S STEAM PRESS OFFICES, NEWHALL STREET.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

SPECIAL GENERAL MEETING,

HELD IN LONDON, ON 30TH JUNE, 1851.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

LONDON:
PRINTED BY WATERLOW & SONS, LONDON WALL.

MDCCCLI.

PROCEEDINGS.

The Special General Meeting of the Members was held at the Rooms of the Society of Arts, John-street, Adelphi, London, on Monday, 30th June, 1851. The President, Mr. Robert Stephenson, having to attend a Committee of the House of Commons, Mr. J. E. McConnell, Vice-President, was called to take the Chair.

The Secretary read the minutes of the last General Meeting, which were confirmed.

The following supplementary paper by Mr. Joseph Beasley, of Smethwick, near Birmingham, was then read:—

ON A NEW MACHINE FOR BLOOMING IRON.

The purpose of this machine is the blooming of the iron from the puddling furnace, in a more rapid, effectual, and economical method than is accomplished by the usual process of hammering or shingling; the machine is the recent patented invention of Mr. Jeremiah Brown (a roll-turner, late of the Oak Farm Iron Works, Dudley).

Other methods have been invented and employed to supersede the hammering process, some of considerable ingenuity and merit; still, unscientific ancient and rough as the process is, shingling or hammering obtains general preference in the blooming of iron; and it has been generally contended hitherto that the hammer excels all other means for ridding iron of its native impurities. This might perhaps be admitted with reference to all other methods hitherto introduced; but for the present machine, differing as it does in construction and action from any one hitherto contrived, there is claimed a decided superiority, in all respects, over the hammer and every other working process for the operation in question.

The blooming of iron is that process which the metal undergoes immediately upon its removal from the puddling furnace, whereby, as effectually and expeditiously as may be, the metal is consolidated

into a homogeneous mass, free from dross or cinder. The principal objection to iron made by the ordinary squeezers is the quantity of cinder which is lapped or enclosed in it; whereas the object of squeezing compressing and hammering, alike is to separate and express the cinder, which in proportion as it remains in the bloom, injures its quality, destroys the fibre of the iron, and prevents it uniting in a complete and uniform manner. It is the process of blooming, in fact, which fixes the character and quality of the iron, since no impurity can be thoroughly eliminated by any after process.

This machine consists of three large spiral-shaped rolls, placed horizontally, and rotating all in the same direction; the ball of iron from the puddling furnace is dropped into the three-sided space between the three rolls, which forcibly compress the ball, giving it a rotating motion; and they have a very powerful kneading action upon the iron, squeezing out the cinder very effectually, which flows freely away down each side of the bottom roll. The space between the rolls gradually contracts from the spiral form of the rolls, thereby maintaining an increasing compression on the iron on all sides and the ends, until it is liberated by the extreme projections of the rolls passing the bloom, which drops out of the machine at the same moment that a second ball is put in at the top. The journals of one of the rolls are made to slide back to prevent injury when any extra size of ball is put into the machine, and they are pressed down by a balance weight acting on two large triple-threaded screws, maintaining a constant pressure on the roll, so that a large or small ball (within ordinary limits) is worked with the same pressure, and in as effective a manner as the regular size of ball.

(See description and engravings of the machine in the Proceedings, April 23rd, 1851, and Plates 28 and 29.)

This machine is simple and not complicated in its construction; it is moderate in the charges of its erection, and, as far as experience serves, safe and ready in its working, since not a single irregularity or stoppage of the machine has occurred from the time it was started in efficient action, a period now of some months.

A most important advantage of this machine is the economy of time effected in the operation of blooming. It accomplishes 5 revolutions

per minute, and turns out one bloom in each revolution, which is at the rate of 12 seconds for each bloom; whereas the time required in the usual process of hammering is from 60 to 80 seconds per bloom, which is thus about 6 to 1 in favour of the machine. By this rapidity of the process of blooming by the improved method, the iron is passed through the bar rolls at considerably greater heat than from the hammer, and is in consequence softer and much better worked in that process, the rolling being performed in the same heat as the blooming.

A valuable consideration is the saving of expense in manufacture. The machine is self-acting, and requires no men to attend the working; whereas the hammer requires an experienced artisan in all instances, and sometimes two, and these men are entirely dispensed with by the machine being self-acting.

In consequence of the increased speed at which the bloom is turned out, being only one-sixth of the time required by the hammer, the machine is capable of working for a much larger number of furnaces, and the puddlers are never liable to be kept waiting for their turns, as is frequently the case where one hammer works for more than eight or ten furnaces. On the contrary, with the machine, the greatest number of furnaces that can be placed in proximity thereto will not be sufficient to employ it, on the average, more than one-quarter of its time, and, therefore, a very great margin is afforded for meeting the unavoidable irregularities in the supply of the balls from the several puddlers, thus preventing the waste and deterioration of the iron from being detained in the furnace until the hammer is at liberty. The writer may observe that he has not the slightest doubt, that iron for various manufacturing purposes, can be made from this process alone; he might instance iron for nail rods, which may be slit without extra heating, thereby avoiding both considerable waste and considerable cost and labour.

The expense in tools is very considerable where hammers are used, and is much greater than with the machine. In consequence of the hot iron being five or six times longer in contact with the hammer and anvil than with the machine, and the hot cinder out of the iron lying upon the anvil instead of falling off constantly as it does in the machine, likewise from the impossibility of applying a constant stream of cold water to the hammer, as is done in the machine; the hammer and anvil

get so very hot where a number of furnaces are working, that they wear out very rapidly, sometimes lasting only a week. They are always liable to break, as is the helve also, and in casualties of this kind the loss is always great. To replace a hammer or anvil when it breaks or fails during the working (particularly when a large number of furnaces are at work), is attended with heavy expense, and the quantity and quality of the iron much diminished, from being detained in the furnace until the repairs are completed and the tools replaced, which sometimes occupies a considerable period of time. In case of fracture of the helve, the loss sustained is still greater, involving as it does the total stoppage of the works until the helve is renewed.

The expense of keeping the machine in repair is very inconsiderable. The small amount of friction in its action and the slowness of its motion prevent any but moderate and trifling wear of the machine; and the maximum power employed in driving not being greater than that for the hammer, the liability to breakage is considerably less; that is, if the several parts of the machine are put properly to work. The machine at the writer's works, which is the only one at present in operation, has continued in constant work since it has been erected, about six months, with scarcely any outlay for repairs, except some incurred at starting, through defective construction of some parts of the apparatus; and the writer is of opinion that the cost of wear and tear will not exceed £20 to £30 per annum, whilst the expense of keeping in repair one hammer, to do half the work of one machine, would be more than ten times that amount.

An effective provision is made to decrease the risk of breakage in the machine, by the proportionately light construction of the driving-clutch, which will give way before any other part can receive injury, and which clutch, if broken, can at any time be replaced in a few minutes.

The saving of power with the machine is next to be noted. The power given out by the engine is only exerted by this machine during one-sixth of the time required by the hammer to do the same work, and during the greater portion of that time the power required in the machine is comparatively small, from the very soft and loose state of the ball, and the full power is not exerted until the revolution

is nearly completed; whereas, with the hammer, the power absorbed is equal throughout the whole of the operation, as the same mass of helve is upheaved at each stroke of the hammer. Less power also is required in rolling the iron from the machine, owing to its greater heat and softness.

For the purpose of ascertaining the actual power expended in working the machine, as compared with the hammer, the following experiments have been tried, and indicator diagrams were taken from the steam-engine employed to drive both the machine and the hammer, as well as the forge-rolls; these indicator diagrams were taken by Mr. C. W. Siemens, who kindly undertook to try the experiments with Mr. Marshall. During these experiments the engine was kept working at a uniform rate of 20 to 21 strokes per minute, and all the other machinery driven by the engine was kept out of use, and the engine was driving the same train of shafting and gearing in all the experiments, making a constant addition to the power exerted in each case.

Figs. 1 and 2, Plate 30, are a series of five indicator diagrams each, taken during the working of the machine alone, showing five successive strokes of the engine. In each instance a series of five blooms was got ready, and the machine was regularly fed with a fresh bloom at each revolution, for the purpose of keeping it in constant steady work, and neutralizing any accelerating force that might be felt at the commencement from the momentum of the fly-wheel of the engine, so as to obtain a correct indication of the power expended in working the machine.

Fig. 1 shows the whole power, from putting in the second ball to putting in the third ball, and fig. 2 from the fourth to the fifth ball of another series. The engine made $4\frac{1}{6}$ double strokes during one revolution of the machine, so that the five strokes shown in the diagrams include the whole process of blooming one ball in each case; but as the machine only compresses the iron during about 2-3rds of its revolution, in consequence of the hollow left in the upper roll for putting in the ball, the power of the engine is exerted only during three strokes in compressing each ball; and it will be seen by Figs. 1 and 2, that these strokes show a progressive increase of power was exerted, as the compression of the ball advanced, and the iron became

harder. The top line in Fig. 1 shows a very sudden increase of power at the last stroke of the engine, indicating the final pinch or extreme pressure exerted at the moment of completing the bloom.

Figs. 3 and 4, Plate 30, show a corresponding series of indicator diagrams, taken during the working of two different blooms under the hammer. The lowest line on Fig. 3 shows the power absorbed by the engine and shafting alone, before the hammer commenced working.

The dotted lines in Fig. 5, Plate 31, show all the lines of Figs. 1 and 2, Plate 30, reduced each to the same horizontal base line, for the purpose of comparing them together, and obtaining the mean of the whole, showing the working of the *machine alone.*

Fig. 6 shows a corresponding comparison and reduction of all the lines in Figs. 3 and 4, being the working of the *hammer alone.*

The full line E in Figs. 5 and 6, shows the power absorbed in driving the *engine and shafting only;* the mean of this is 3.70 lbs. pressure per square inch, and this portion is shaded on each of these Figs. 5 and 6, and also on the following Figs. 7 and 8.

The full line P on Fig. 5 shows the mean of all the indicator diagrams, so that the space between the mean total power P, and the power absorbed by the engine and shafting E, expresses the mean power actually expended in *driving the machine;* this averages 0.84 lbs. pressure per square inch, or $8\frac{3}{4}$-horse power.

Fig. 6 shows in the same way by the *full line* P, the mean power expended in *driving the hammer,* and the average is 2.40 lbs. pressure per square inch, or $24\frac{3}{4}$-horse power.

But the machine completes each bloom in 12 seconds, whilst the hammer takes from 60 to 80 seconds for the same process. Consequently, the comparison of the total power is 105 ($8\frac{3}{4} \times 12$), to 1732 ($24\frac{3}{4} \times 70$), being a proportion of 1 to $16\frac{1}{2}$ in favour of the machine; showing the power required to work the hammer to be $16\frac{1}{2}$ times as great as that required to do the same amount of work with the machine.

A similar comparison was also made between the machine and the hammer, when each was worked in combination with the forge-rolls, as is the case in ordinary working.

A series of five indicator diagrams was taken during the working of the machine and forge-rolls combined, with a continuous succession of ten balls passed directly from the machine through the rolls; the rolls could not, however, work fast enough for the supply of blooms from the machine, although three blooms were in the rolls at once, as the one machine would be capable of keeping up a constant supply of blooms for three pair of rolls. The *dotted lines* in Fig. 7, Plate 31, show these diagrams reduced all to the same base line, for the same purpose as Figs. 5 and 6.

A corresponding series of five indicator diagrams was also taken during the working of the hammer and forge-rolls combined, whilst one bloom was under the hammer and the previous one was in the rolls. These diagrams showed the highest pressure exerted during the operation, as the indicator dropped again to the lowest line in each instance after the completion of the highest line. The *dotted lines* in Fig. 8 show these diagrams reduced to the same base line as before.

The *full line* E., in Figs. 7 and 8, shows the power absorbed in driving the *engine and shafting only*, the same as in Figs. 5 and 6, this portion being shaded to correspond.

The *full line* P., on Fig. 7, shows the mean of all the indicator diagrams, and the space between the lines P and E, expressing as before the mean power expended in *driving the machine and rolls*, averages 7.13lbs. pressure per square inch, or 64-horse power.

The *full line* P on Fig. 8 shows in the same manner the mean of all the indicator diagrams, and the space between the lines P and E expressing the mean power expended in *driving the hammer and rolls*, averages 9.43 lbs. pressure per square inch, or 84¾-horse power.

The comparison of these results cannot be made in the same manner as the former results, from the machine and the hammer alone; as the time of each process of rolling was different from both of them, being about 40 seconds, and the iron from the machine could not be rolled so fast as it was bloomed; but it may be observed that the total increase of power exerted to drive the rolls was actually less in the case of the machine than in that of the hammer, although there were three bars in the rolls at the same moment with the machine, but only one bar at a time with the hammer; showing the great saving in the power required to roll the iron from the machine as compared with

that from the hammer, in consequence of its much hotter state when brought to the rolls.

An important improvement in the quality of the iron is effected by the machine, which arises from the cinder being more thoroughly and minutely squeezed out of the metal in its progress through the machine, and from the powerful kneading and indenting action of the three rolls throughout the revolution of the machine whilst the iron is in a welding state, the effect of which is to increase the density and solidity of the metal, and to unite and bind the grain of the iron more effectually than can be done by the hammer. This action of the machine on the body of the bloom is constantly exercised; but in the case of the hammer, the greater portion of the time is wasted in the lift and fall of the hammer, and this time is of great importance, as the hotter and more fluid the cinder is, the more completely can it be squeezed out from the body of the iron. The action of the machine is clearly shown by the accompanying sectional model, and it will be seen that the ball is made to take a somewhat triangular form by the pressure of the three rolls, and that every particle of the iron, in its turn, is, by the revolution of the ball, subjected to the kneading action of the rolls, and is thereby first pressed in towards the centre of the mass, and again squeezed outwards by the pressure that other particles are subjected to, thus giving great facility for the escape of the cinder from every part of the ball, and forcing it out in a more effective manner than the ordinary process of working a four-sided bloom under the hammer. It may also be remarked, that when it happens that iron is not properly worked in the puddling-furnace, or is prematurely taken therefrom, the imperfect puddling is shown in this machine by large cracks or fissures in the bloom, or the bad portion is forced in irregular projections to the surface, and is not enclosed in the mass of the bloom.

Mr. Beasley said he had made some further experiments as to the strength of the iron manufactured by this process, as requested at the last meeting, and although they had been but few, they would be considered, he thought, quite satisfactory. Four bars, 1⅛-inch diameter, had been made in the same manner, and from the same iron, from the hammer as from the machine, both being made out of the same heat of the furnace. They were tested by Mr. H. Parkes' hydraulic press at Tipton for proving chain cables, and the first bar from the machine indicated a strain of 26½ tons before it broke. The first bar made by the hammer bore 27½ tons; the second from the machine, 26 tons; the second from the hammer, 25½ tons. He then tested two bars 1⅛-inch diameter, which had been piled; that from the machine bore 25½ tons, and the one from the hammer also 25½ tons. He also tried two bars of 1½-inch diameter, which had been piled; that from the hammer indicated 38 tons; that from the machine, 40 tons. It appeared, therefore, that there is no material difference in strength between the bars made from the hammer and those from the machine. But for other descriptions of iron he thought the machine much better than the hammer. He exhibited some specimens of hoops, of very tough quality; also specimens of other descriptions of iron, all bloomed by the machine.

A model of the machine was exhibited; also a sectional model, in which the operation was shown by a ball of putty.

The Chairman inquired whether Mr. Beasley had ascertained the relative cost of the two different processes of manufacture.

Mr. Beasley said he had not gone minutely into the matter; but it was known to every iron manufacturer that the expense of the hammer is very considerable, the wear and tear and the breakage of tools and helves, amounting to an expense of at least 1s. per ton. He found the machine saved in wages about 15d. per ton, besides the saving in power and in repairs; but in larger works the saving would be proportionately greater. Where there

were a great many furnaces to keep the machine regularly at work, the saving would be very considerable; but he had not a sufficient number of furnaces adjoining the machine to keep it fully at work.

Mr. Blackwell had seen the machine in operation, and was convinced of its advantages. There was no doubt in his mind that the cinder is more perfectly extracted from the bloom by the machine than by the hammer; and he thought there was no doubt that the quality of the iron was better. He quite agreed with Mr. Beasley as to the saving in the cost of manufacture.

Mr. Adams had also seen this machine at work, and was satisfied as to its efficiency; and believed the bloom was as good as that produced by the hammer. But he found the cinder still exuded in considerable quantity from the two ends of the bloom, when it received an end blow under the hammer; and he thought a better quality than the ordinary iron from the hammer would be obtained by putting the bloom under the hammer immediately after it comes from the machine, to expel the remaining cinder.

Mr. Beasley thought that in the case referred to, the ball must have been below the proper limit of size, and consequently not fully worked in the machine; which would account for some cinder remaining. A variation of about 20 lbs. was allowed from the standard weight of each ball (about 90 lbs.), which was found quite sufficient with good puddlers, and was allowed for by the yielding of the weight on the screws of the machine. The cinder was still in so hot a state, after coming from the machine, as to be squeezed out by the rolls, and the greatest possible quantity of cinder was taken out by the rolls; so that, in fact, they effected what would be done by using the hammer in addition to the machine.

Mr. Blackwell thought the rolls squeezed out any remaining cinder, and remarked, as a test of the superior action of the machine in separating the cinder, that the yield under the

machine is less than under the hammer; the weight of iron produced, of course depending upon the quantity of cinder squeezed out.

Mr. ADAMS did not mean that the machine did not do the work as efficiently, and turn out as good a bloom as the hammer; but he thought that with the addition of the hammer a still better quality of iron might be advantageously produced than was at present manufactured, instead of reducing the expense.

Mr. BEASLEY exhibited specimens of blooms, of the ordinary make, from the machine and the hammer; he had had a considerable number of them sawn through and polished; and had not detected any flaw in those from the machine; he thought they were at least as free from cinder as those made under the hammering process, and that no cinder was remaining in the body of the iron. Under the hammer a lap was sometimes formed, by one of the edges of the square bloom being turned over, which is injurious to the iron, as it makes an unsound place or a hollow, in which some of the cinder is lodged, and cannot be driven out afterwards. A specimen of this kind was exhibited, a section of which is given in Fig. 1, Plate 32, showing the hollow in the body of the iron. Fig. 2 shows a good bloom from the hammer, and Fig. 3 the section of a bloom from the machine.

Mr. COWPER illustrated, by a model, the mode in which the iron is kneaded by the action of the three rolls, and the cinder squeezed out from the whole of the mass. He said that he had observed the working of the machine, and was satisfied that the cinder was thoroughly squeezed out from the body of the iron. The hammer often chilled the surface of the bloom, which to a certain extent, enclosed the cinder, but in the machine the cinder ran out very freely; and when that iron was rolled into bars, the cinder did not squeeze out of the ends, as is the case with the iron bloomed with the hammer; in fact so much so, that in rolling the blooms from the hammer the men always

stand on one side, to get out of the way of the cinder flying out of the ends; but with the blooms from the machine he had never seen any cinder squeezed out from the ends in rolling, or if any it was very trifling indeed, although the iron was in a much hotter state when rolled than that from the hammer.

Mr. HODGE said he could see the great advantage of this machine, but he thought the quality of the iron might be further improved by putting the bloom under the hammer after it comes out of the machine—but not the old style of hammer.

Professor HODGKINSON said he thought the machine was a most ingenious process; but notwithstanding the good appearance of the iron, he felt a doubt whether it was quite so efficient as the hammer in squeezing out the cinder; but he had not sufficient information to speak from, as he had not seen the working of the machine. The appearance of the iron was certainly excellent; and there was great ingenuity shown in the machine.

Mr. BEASLEY wished to make one other remark relative to the heat of the bloom as it comes from the machine. He thought it was possible to make a good weld under the hammer, of two of the blooms from the machine; he therefore tried two balls in rapid succession, and brought them to the hammer, when as good a weld was made as if the iron had been brought direct from the furnace. He believed iron manufactured in that way would save a great deal of expense in making rails; and the iron could be rolled at once without a second heating of the metal.

The CHAIRMAN observed that it was important that there should be a comparative test made of the quality of the iron as prepared by the machine, and that by the ordinary process of the hammer; and he suggested to Mr. Beasley to make a piece of iron, as well as he could under his process; and get another manufacturer to make a similar piece under the old process of hammering: the two specimens might be then submitted to Professor Hodgkinson for examination of their comparative merits.

Mr. BEASLEY said there might be a material difference in the quality of the specimens of iron, independent of the difference

in the process of blooming, which would interfere with the results of the experiment. But he should be glad to try the experiment of the two processes, by taking iron from the same furnace, at the same heat; and if one ball was taken to the hammer and another to the machine alternately, and then the iron of each tested, he thought that would be a fair trial. He would be ready to go through a series of experiments for the purpose.

Mr. Hodge thought Mr. Beasley's proposition would be the only fair plan of testing the two processes of manufacture.

Mr. Blackwell also thought the proposition a very fair one; and the comparison could only be made from the same starting point of the iron in the puddling furnace in each case. Even if the same ore were used, heated with the same description of coals, in two different furnaces, the working of the furnaces alone might make such a difference as to prevent the manufacturing of the same quality of iron in each, however carefully the materials were adjusted; and this would destroy the accuracy of any comparison.

Mr. Scott Russell remarked, that even if Mr. Beasley made no better iron by his machine than had been done heretofore by the hammer, he thought he had done a great deal in bringing the iron to a state to undergo the subsequent processes by more economical means.

Captain W. S. Moorsom hoped the experiment would also be tried that had been suggested, of obtaining an improved quality of iron by the subsequent process of hammering in addition to the machine, so that a material of greater strength might be obtained if possible.

Mr. Beasley said he would be glad to go into that matter; undoubtedly the iron might be improved for some purposes by subsequent hammering, as suggested; but for general purposes, he thought it would be useless, and an extra expense without any corresponding advantage.

The Chairman proposed that any gentlemen who felt inter-

ested in the subject should communicate with the Secretary, and arrange the further experiments to be conducted at Mr. Beasley's works, and bring the results before the Institution.

A vote of thanks was then passed to Mr. Beasley for his communication.

The following paper by Mr. Paul R. Hodge, of London, was then read.

ON THE PROGRESS OF IMPROVEMENTS IN LOCKS IN THE UNITED STATES OF AMERICA.

It is seldom that any skilful mechanical arrangement of parts to carry out certain effects is the production of one mind, or one pair of hands; nor do we find that mechanical genius is confined to one country or any distinct race of beings. Perhaps there is no machine more ancient than that of a lock; but it appears that, until about the year 1774, very few improvements had been made in the construction of locks in this country, although the basis or principle on which all modern locks are constructed can be traced back more than four thousand years. The three principal locks manufactured in England, for the last thirty years, are those of Barron, Bramah, and Chubb; the inventions of each of which are based on the principle of the old Egyptian lock, the difference between them being only in the mechanical arrangements of parts to produce the same effect. The present communication is intended to show the insecurity of English locks generally, and to bring under the notice of the Institution the ingenious lock of Mr. Newell, of New York.

It was conceded, about twelve years since, in the United States, by all locksmiths, that a lock having a series of tumblers or slides, such as was used at that time in Europe, and more particularly those of Barron and Chubb, was secure against all known means of picking, or of forming a false key by any knowledge that could be obtained through the key-hole. The only point that seemed desirable was, to make it secure against the maker, or any party who might have had possession of the key, and from it taken an impression.

The first step, therefore, was to construct the lock so that the party using it could change its form at pleasure.

The most successful locksmith, for a time, was a Mr. Andrews, of Perth Amboy, in the State of New York; he constructed a lock similar to that made by Mr. Chubb, having a series of tumblers and a detector; but before placing the lock on the door, the purchaser could arrange the tumblers in any way, so that the combination suited his convenience; the key being made with a series of movable bitts, was arranged in a corresponding combination with the tumblers.

In order to make a change in the lock without taking it from the door, each tumbler was so constructed that *in locking the lock* the tumbler could be raised, or drawn out, with the bolt. A series of rings was furnished with the key, corresponding with the thickness of the movable bitts of the key; and any one, or as many more of the bitts could be removed from the key, and rings substituted. These bitts being removed, and the rings taking their place, the corresponding tumblers would not be raised by the turning of the key, and consequently, would be drawn out with the bolt *(becoming, in fact, a portion of the bolt itself)*. Therefore, when a bitt was removed and a ring substituted, so much of the security of the lock was lost as depended on the tumbler that was not raised; consequently, a lock having twelve tumblers being locked with a key with alternate bitts and rings, would evidently become a six tumbler lock; but should a tumbler that was drawn out with the bolt, be raised in the attempt to pick or unlock it, or should any one of the *acting tumblers* be raised too high, the detector would be thrown, and prevent the withdrawing or unlocking of the bolt. This lock was in great repute in the United States, and was placed on the doors of nearly all the principal banking establishments of the country; a large reward was offered by its maker to any one who could pick it; and from its great repute, it consequently called out many rivals.

Mr. Newell, of the firm of Newell and Day, of Broadway, New York, was the most successful competitor, by constructing what he termed his Permutating Lock, which was composed of a series of *first and secondary tumblers, the secondary series being operated upon by the first series.*

Through the secondary series there was passed a screw termed a clamp screw, having a clamp overlapping the tumblers on the inside

of the lock; each tumbler in the series having an elongated slot to allow the screw to pass through. On the back side of the lock was a small round key-hole, in which the head of the screw rested, forming as it were a receptacle for a small secondary key; so that when the large key gave the necessary form to the tumblers, the party took the small key and operated on the clamp screw, clamping and holding together the secondary series, retaining them in the relative heights or distances imparted to them by the large key; the door was then closed, and the bolt projected, and the first series of tumblers fell again to their original position.

The objection to this mode of constructing a lock was, that it required the insertion of the small secondary key; and should the party neglect to release the clamp screw every time he unlocked the lock, the *first series* of tumblers would be *held up by the secondary series.* Consequently, an exact impression of the lengths of the several bits of the key could be obtained *through the key-hole* while the lock was unlocked.

Another and a more convenient method was devised by Mr. Newell. On each of the secondary tumblers he made a series of *notches*, corresponding in distance with the difference in the lengths of the several bitts of the key (see DD in Figs. 1 and 2, Plates 33 and 34); on turning the key each bitt raises its plate or tumbler, so that some one of the notches presents itself in front of the tooth on a dog or lever (HH). As the bolt is projected, the tooth being pressed into the several notches, the secondary series are held in their position by the tooth of this dog or lever, as shown in Fig. 2, thereby doing away with the necessity of the secondary key. In unlocking the lock the tooth is again detached, and the tumblers all fall to their original position, and the lock again becomes a blank, as in Fig. 1.

It will be seen that there was no improvement in the actual *safety of the lock against picking,* the only object being to make a lock that could be changed by the party using it, in the most effectual manner.

These improvements were all made prior to the year 1841; so that ten years ago many very valuable additions had been made to the detector and tumbler lock.

In the course of Mr. Newell's studies, he conceived that the lock

of his competitor, Mr. Andrews, might be picked; and the result was the picking of it by a very simple instrument, which is exhibited to the meeting. (See Figs. 8 and 9, Plate 33.)

Mr. Newell immediately afterwards picked his own, with an instrument of a similar construction; so that, in investigating the principle by which he could pick the lock of his rival, he discovered also means by which he picked his own; and his candour in this affair was certainly greatly to his credit, in making it known at once, and not concealing that his lock, as well as *all others based on the tumbler principle, was insecure.*

The question, then, was with him and other makers of locks, in what way should they make a secure lock?

The first step taken was to add a series of *complicated wards to the lock;* but it will be readily seen that what can be reached with a key could be reached by some other instrument; and although it required an instrument of a different form, yet the operation was just as *certain, and fatal* to the security of the lock.

The next step taken, and one which was considered effectual, for a time, was the *notching of the abutting parts* of the first and secondary series of tumblers, or of the stump face and the ends of the tumblers. So that if a pressure was put upon the bolt, the tumblers could not be successively raised by the picking instrument being held fast by these "false notches." This lock baffled the skill of all the country for a time, and was considered perfectly safe, until an ingenious engineer of the name of Pettis informed Messrs. Newell and Day that he believed it was possible to pick their lock. They immediately put their lock to the test, by putting it in a room in the Merchants' Exchange, in Wall-street, New York, offering a reward of 500 dollars, or 100 guineas, to any person who could pick it, allowing them the privilege of *examining the lock as long as they wished, and giving them their own time to make their experiments.*

The result was, that Mr. Pettis accepted the challenge; the lock was picked; and Messrs. Newell and Day lost their 100 guineas. But that was not all; their reputation as locksmiths went also.

The lock in question is now in the United States department of the Great Exhibition, and can be examined by any person; its workmanship is beautiful, and it contains all the points of security hitherto

known and used in tumbler locks: it has sixteen tumblers, a detector, and false notches; yet Mr. Pettis overcame all these obstructions, and picked it fairly.

What was then to be done? The alarm can be readily conceived of every banker, merchant, or broker, that supposed that they had a sure protection in that lock.

The only reasonable conclusion by Mr. Newell was, that security could be obtained, not by *adding difficulties*, because *difficulties could be overcome*, but by constructing a lock so that the *obstructions to the withdrawing of the bolt cannot be ascertained through the key-hole.*

Upon this principle, and with this object in view, the Parautoptic lock, as shown in Plates 33, 34, and 35, was invented by Mr. Newell, retaining all that was deemed good in the locks previously made, and at the same time guarding against all the defects proved by actual experiment. A specimen of this lock is exhibited to the meeting.

Fig. 1 represents the lock unlocked, with the cover or top-plate removed, also the auxiliary-tumbler and the detector-plate are removed.

Fig. 2 shows it locked, with the cover and the detector-plate removed, and the auxiliary-tumbler in its place.

Fig. 3 is the lock with the cover on, showing the detector-plate.

Fig. 4 is a section of the lock taken through the key-hole, showing a transverse section of the tumblers and the bolt.

Fig. 5 is the key; and Fig. 6 an end view of the key, showing the screw by which the separate bitts are fixed in the key. Fig. 7 shows the six bitts of the key detached; and Fig. 8 shows the same key as Fig. 5, but having the bitts arranged in a different succession, thus forming a different key.

AA in Figs. 1, 2, 3, and 4, is the bolt. BB are the *first series* of moveable slides or tumblers, C the tumbler springs, DD the *secondary series* of tumblers, and EE the *third or intermediate series*, which form the connections between the first and secondary series of tumblers. FF are the separating plates between the first series of tumblers; G the springs for lifting the intermediate slides or tumblers, to make them follow the first series when they are lifted by the key. On each of the secondary tumblers DD, is a series of notches, corresponding in distance with the difference in the lengths of the moveable bitts of

the key; and as the key is turned in the lock to lock it, each bitt raises its tumbler, so that some one of these notches presents itself in front of the tooth *h* on the dog or lever HH. As the bolt A is projected, it carries with it the secondary tumblers DD, and presses the tooth *h* into the notches in the tumblers, withdrawing the tongues *d* from between the jaws *ee* of the intermediate tumblers EE, and allowing the first and intermediate tumblers to fall to their original position; whilst the secondary tumblers DD are held in the position given to them by the key, by means of the tooth *h* being pressed into the several notches, as shown in Fig. 2. Should an attempt be made to unlock the bolt with any but the true key, the tongues *d* will abut against the jaws *ee*, preventing the bolt from being withdrawn; and should an attempt be made to ascertain which tumbler binds and requires to be moved, the secondary tumbler DD that takes the pressure, being behind the iron wall IK which is fixed completely across the lock, prevents the possibility of its being reached through the key-hole, and the first tumblers BB are quite detached at the time, thereby making it impossible to ascertain the position of the parts in the inner chamber behind the wall IK. The portion II of this wall is fixed to the back plate of the lock, and the portion KK to the cover.

L is the drill-pin on which the key fits; and MM is a revolving ring or curtain, which turns round with the key, and prevents the possibility of inspecting the interior of the lock through the key-hole; and should this ring be turned to bring the opening upwards, the detector-plate QQ, (see Fig. 3,) is immediately carried over the key-hole S by the motion of the pin P upon the auxiliary-tumbler OO, which is lifted by the revolution of the ring M, thereby effectually closing the opening of the key-hole. As an additional protection the bolt is held from being unlocked by the stud R bearing against the plate Q; also the lever TT holds the bolt when locked until it is released by the tail of the detector-plate Q pressing the pin U. V is a dog holding the bolt on the upper side when locked until it is lifted by the tumblers acting on the pin W. XX are the separating plates between the intermediate tumblers EE; Y and Z are the studs for preserving the parallel motion of the different tumblers.

There are several features in the construction of this lock which are deserving of particular attention. The most novel and extraordinary

is, that the lock changes itself to the key; in whatever form the moveable bitts on the key are changed, the lock answers to that form, without moving any part of it from the door.

The party purchasing the lock can change it to suit his convenience. If a 6-tumbler lock, to 720; if 7 tumblers, 5,040; if 8, 40,320; if 9, 362,880; if 10, 3,628,800, and if 12, 479,001,600. Therefore it will be perceived that, by changing the numerical position of the bitts in the key, the lock can be altered, or in fact alters itself to any number of new locks, equal to the permutation of the number of bitts on the key. Two extra bitts are supplied with each key, which add very greatly to the number of changes. As the key turns round, each bitt raises its tumbler to a point corresponding with its length, imparting to the first and secondary series the exact form of the key. The secondary series of tumblers being carried out with the bolt, and the tooth on the lever or dog being pressed into the several notches on the front face of the secondary series, holds them in the position given them by the key, while all the other portions of the lock fall again to their original position.

Should a pressure be put on the bolt to ascertain the obstruction, it will be readily seen that it will be brought to bear on the third or intermediate tumblers. To prevent the possibility of reaching these, there is a wall of metal fixed across the lock, which confines the operator wholly to the key-chamber. By detaching the portion of the tumbler that takes the pressure given to the bolt from the parts that can be reached through the key-hole, leaving that portion always at liberty, the possibility of ascertaining what is wrong is cut off; so that instead, as in the former lock, having only a *first* and *secondary series*, Mr. Newell here introduced a *third or intermediate series;* thereby throwing the whole security of the lock into a chamber beyond the wall of metal, which is wholly inaccessible, and forming as it were another lock without a key-hole. These are the principal features of security in Mr. Newell's Parautoptic Lock.

There is another source of insecurity that has still to be provided against: when the first tumblers can be seen through the keyhole, if the underside of them is smoked by inserting any flame, the key will leave a distinct mark upon each tumbler the next time it is used, showing where it began to touch each tumbler in lifting it. This can be seen

by inserting a small hinged mirror into the lock through the key-hole, and the exact length of each bitt of the key measured, from the centre-pin to the point where it touched the particular tumbler, from which a correct copy of the key can be made. (An electric light from a small portable battery has been employed for this purpose, to illumine the interior of the lock.)

The possibility of seeing the tumblers is entirely prevented by surrounding the inside of the key-hole with the ring or revolving curtain; and when this curtain be turned, to bring the opening opposite the tumblers, the key-hole is shut on the outside by the detector tumbler, which tumbler would also detect all attempts at mutilating the interior parts of the lock.

Should the lock be charged with gunpowder, through the key-hole, for the purpose of blowing it from the door, the plug in the back of the key chamber yields to the force, leaving the lock uninjured, whilst the curtain protects the interior of the lock from injury, thereby effectually preventing all known means of opening or forcing the lock.

Mr. Hodge begged to observe, that although he had been drawn into a controversy upon the subject of locks, he had not any personal interest in any lock, nor had ever invented any portion of a lock; and he had taken up the matter purely as a mechanical question, and one, he thought, of very general interest. He had, therefore, brought before the meeting the description of the very ingenious lock of Mr. Newell, and the progress of the invention of the previous American locks; and begged to refer to the report upon the lock by the Mechanics' Institute of Lower Austria, by whom Mr. Newell was presented with a gold medal for the invention.

Mr. Chubb said he considered that he had been treated with unfairness in the trial that had been made of his lock, and complained of the manner in which the lock that had been picked was procured from him.

The Chairman remarked, that the object of the discussion was to ascertain the relative merits of the American lock des-

cribed in the paper that was before the meeting, and the discussion should be confined to the mechanical part of the question.

Mr. Chubb wished to explain that the lock and keys which Mr. Hobbs had picked, were purchased by Mr. Hobbs, and remained seven days in his possession before the trial took place; and any lock might, in a few hours, be made safe to be picked. He wished to show that it had not been done in a fair way. He had given in the *Times* newspaper a public challenge to Mr. Hobbs to come and pick one of his locks, which he had put upon a door for the purpose, but that had been declined. He denied emphatically that any one could pick, within any reasonable time, one of his locks which had not been tampered with.

Mr. Chubb then produced two locks, which he said were of his ordinary make, and offered that they should be examined by the Chairman and Mr. Scott Russell, to ascertain that there was no unfairness about them, and then put upon a door, and that Mr. Hobbs might come one day to take the impression of the keyhole, and then come five hours any day during the week, and pick the locks if he could.

Mr. Scott Russell said he thought that was the definite point to be arrived at. He had not been acquainted with the American lock before, and was much struck with its ingenuity and perfection. He certainly considered it to be unpickable, and had a fear that Mr. Chubb's lock was pickable, and he was glad to hear of the present offer; if Mr. Chubb liked to put those locks on the table, with the challenge to pick them, and they were not picked, it would be a practical illustration of the excellence of the locks. He suggested that it would be most eligible for the Council of the Institution to appoint a committee of two or three qualified persons to act as arbitrators in the trial.

The Chairman remarked that the object of the paper being read at the meeting, was to ascertain the relative merits of the different kinds of locks; but it was not advisable that the Insti-

tution should do more in this matter than afford an opportunity for a fair and open discussion, and also for recording the facts of any experimental trial of the different locks. The discussion had now brought them to the point of Mr. Chubb bringing forward his lock, and offering to the American lock-maker an opportunity to try and pick it.

Mr. Hodge said he considered the only fair trial would be, to take one of the locks made for regular sale, not one made on purpose for this trial; and he proposed that the trial should be made with a lock which had lately been purchased from Mr. Chubb's shop, with this object, by an independent party, Messrs. Dew, of Cheapside. This was a legitimate first-rate lock of Mr. Chubb's make, and had been kept sealed up ever since it was purchased, and Mr. Hobbs had never seen it. He proposed that this lock be placed in the hands of a committee, with the approval of both parties, and Mr. Hobbs be allowed an opportunity for picking it.

Mr. Chubb said that in a set trial, he would not be bound to any lock which another person had obtained from him for that purpose.

Mr. Scott Russell suggested that it would be most satisfactory for two or three mechanical men to be appointed a Committee, to settle what should be the terms of the trial, which should be fair to both parties, as a test of the respective locks. That would be an *experimentum crucis*, to bring the question to a settlement.

Mr. Hobbs begged to explain that he had not come over to this country for the purpose of picking locks, but to dispose of his own lock. He was a lock manufacturer; and in the course of explaining the merits of his own lock, it was necessary to show that the lock of another maker was insecure, and he had to prove the assertion practically, by showing that the other lock could be picked. He did not refer to Mr. Chubb's lock in particular, but to the general principles of tumbler locks in this country,

which he maintained were insecure and could be picked; and in his own lock the insecurity that he alleged in other locks was guarded against.

The challenge respecting his own lock, was that a party might take any commercial lock, examine it as much as he pleased, without limit of time, and take the lock to pieces and put it together again, in the presence of competent persons; the lock to be then locked in their presence, and if the party could pick it in any time and after any number of trials, a prize of £1,000 would be given. With regard to the mode of picking the regular tumbler locks, it was a plain mechanical operation with the instrument that had been described.

Mr. Chubb requested that the terms of his challenge might be taken down by the Secretary, who replied that he had done so.

Mr. Geach said he thought as so much was involved in the question, they should give every assistance in setting it right: the greater number of persons who had locks had not the means of knowing whether they were secure or not. A paper had been read to the Institution, in which it was stated that Chubb's and other locks could be picked, not only by Mr. Hobbs, but even by apprentice boys; and therefore he thought the question ought to be set at rest by conclusive experiments, not upon any lock specially made for the purpose, but upon locks which are sold to the public as safe locks. He thought if such experiments were tried before competent persons selected from the Institution, it would be very satisfactory to the public, in order to ascertain, whether the ordinary locks with ordinary facilities for picking were pickable or not.

A Member wished to ask whether Mr. Hobbs did not pick one of Mr. Chubb's locks, at the Exhibition, in seventeen minutes?

Mr. Hensman replied that Mr. Hobbs had done so, and the lock, he believed, was the same as the one laid before the meeting. He examined the lock, and believed it had not been tam-

pered with in any way; he then locked it, and in seventeen minutes Mr. Hobbs picked it fairly in his presence, with the description of tool that had been shown to the meeting. He thought that Mr. Chubb should examine the lock, to see that it had not been tampered with; he understood that the lock had been purchased by Mr. Hobbs for the purpose, at Mr. Chubb's shop.

Mr. Appold remarked that he was also present at the trial, and he confirmed Mr. Hensman's statement. The number of the lock was 142,352.

Mr. Hobbs observed, that it had been objected that the lock just referred to had been in his possession some days before he picked it; but if it was in the same state then as when it was bought, that did not affect the question; and it was now laid before the meeting. He had picked it at the Exhibition, in the presence of a party of gentlemen, only for the purpose of showing the principle upon which tumbler locks could be picked; he had never taken the tumblers from the lock, nor altered the lock in any way, and had merely fitted his instrument to the keyhole, in the same way that it could be done if the lock were fixed on a door. If any party of gentlemen will purchase one of Mr. Chubb's locks, a fair commercial lock, place it under seal, and fix it upon a door, he was ready to go and pick it; the lock to be examined previously by the parties and by Mr. Chubb, to ascertain that it was a fair representation of that principle of locks.

The Chairman said he thought the question had better be left to be settled, as had been suggested, by a Committee appointed by the parties themselves, independent of the Institution, to avoid involving the Institution in any contest of mechanical skill; the members of the council would be glad to assist, and he hoped the facts of the experiments would be laid before a future meeting.

He proposed a vote of thanks to Mr. Hodge for his interesting paper, which was passed.

A paper by Mr. Henry H. Henson, of London, "On Improvements in the Construction of Railway Waggons," was partly read, and the further consideration of it was adjourned to the next meeting. The meeting then terminated.

After the meeting, a party of one hundred and seventy of the Members and their friends dined together at the Freemasons' Tavern, including a number of Foreign Engineers and Jurors of the Exhibition, who had been invited on the occasion by the Members of the Institution, in celebration of the period of the Great Exhibition of the Industry of all Nations. The President of the Institution, Mr. Robert Stephenson, M.P. occupied the chair, and in the course of the evening, the company was addressed by General Poncelet, General Wilson, Colonel Morin, Count Rosen, M. Weidtmann, Mr. James Walker, C.E., Mr. William Keogh, M.P., Mr. Joseph Locke, M.P., Mr. James MacGregor, Mr. J. Scott Russell, Mr. Wyndham Harding, Mr. John Penn, and Mr. Charles Geach, M.P.

Waterlow and Sons, Printers, Carpenters' Hall, London Wall, London.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 30TH JULY, 1851.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:

PRINTED AT M. BILLING'S STEAM PRESS OFFICES,

74, 75, & 76, NEWHALL STREET.

1851.

PROCEEDINGS.

THE GENERAL MEETING of the Members was held at the House of the Institution, Newhall Street, Birmingham, on Wednesday, 30th July, 1851, J. E. McCONNELL, Esq., Vice-President, in the Chair.

The SECRETARY read the Minutes of the last General Meeting, which were confirmed.

The following paper, by Mr. HENRY H. HENSON, of London, was then read:—

ON IMPROVEMENTS IN THE CONSTRUCTION OF RAILWAY WAGGONS.

UNTIL very recently, it could scarcely be said that this subject had been fairly entered upon; and it had received but little attention, except from those whose experience had been derived from the construction and working of common road carriages, which, however valuable for the purposes for which they were designed, were based on totally different principles from those required for the Railway traffic of passengers and goods.

Amongst the early contributors to the production of the Railway Waggon, were included the great carriers, their agents, road contractors, farmers, builders, wheelwrights, salesmen, graziers, timber merchants, and others, who differed greatly in their opinions as to what was wanted. Their individual experience, though highly valuable in reference to their respective departments, required, in order to elicit any practical result from this mass of information, to be blended and digested by others more experienced in the practical working of the new system.

One of the greatest evils inflicted upon the Railway Companies,

has been the absence of arrangement or consultation between the officers of the different lines, in order to consider the best construction of the various vehicles intended to be used in the conduct of their traffic. The result has been, that several Companies have built a class of stock to some extent unsuitable to work conjointly the business of their own and other lines. So serious are the evils resulting from this most unfortunate state of things, that it actually at this moment prevents that extent of improvement being carried out of which the system is capable. The consequences of this want of some common plan of action are most expensively felt. The Institution of Mechanical Engineers has proved highly useful in practically investigating railway machinery, and has greatly promoted safety and economy by full discussion and inquiry.

The purpose of this paper is, an attempt to show the progress of construction in Railway Waggons, explaining the gradual changes enforced by circumstances and experience. The writer may here remark, that his attention was first called to this subject by the daily exposure of the merchandise to certain damage, and the constantly recurring loss to the Railway Companies, from the primitive mode in which the conveyance of the valuable traffic was conducted.

The original form of Goods Waggon generally employed on Railways, from the opening of the Liverpool and Manchester line, in 1829, and for many years afterwards, was nothing more than a platform upon wheels, about 10 feet long, with sides varying from four to ten inches high above the floor level. Indeed many of them are still employed, and for certain portions of the traffic, such as minerals, casks, stone blocks, iron pipes, and sundries, they are as well adapted, as they are unfit unprofitable and dangerous if employed in the conveyance of the merchandise generally. The load per waggon was about 2 tons; the weight of the waggon from about 2½ to 3½ tons.

The want of perfection, or unfitness, of the low open Waggon was very early perceived, and the improvement required faintly foreshadowed by the addition of portable sides and ends,

which were merely open crib-rails, dropped in staples at the sides and ends of the Waggon, and secured at the corners by hooks and eyes. To this slight improvement was soon added the worst evil of all, the inflammable and expensive tarpauling, the use of which has involved such costly contingencies. The most striking defect common to the open Waggons, is the facility with which large bales fall from the trucks upon the line, whereby numerous accidents have arisen. In shunting and starting the train, it is clearly impossible that the goods can keep their position on the floor of the Waggon, without the protection of sides and ends.

The crib-rails and tarpaulings are not only very costly, considering they fail to answer the purposes of safety and protection, but their use has entailed great danger and expense. Serious accidents have happened from the negligent way in which the portable sides and ends are suffered to lie about the Railway; the falling of them from the Waggons is an occurrence which has been attended with serious derangement of the traffic. Trouble and expense are also constantly recurring from the great labour of taking down and refixing the crib-rails to the Waggons; and if it be said they are not always removed, then the trouble of loading and unloading must be greatly increased. Neither can the important item of repairs be said to be moderate, if considered, as it should be, in relation to imperfect service, maintenance of crib-rails and tarpaulings—admittedly different articles, but all of them needful to the completion of this most imperfect Waggon; to which may be added claims for damage done to the goods carried by these trucks.

Fig. 1, Plate 36, shows the improved Open Goods Waggon used upon railways at the present time; it has fixed high sides, with doors at the end, and is covered with a tarpauling.

The faults of the tarpauling are so well known to all connected with the practical use attempted to be made of it, that the writer will only observe, that its employment should only to a very limited extent have been permitted in the conduct of the Railway traffic. In a conversation with one of the great carriers, he was

informed that the yearly cost of tarpaulings to the firm was £3,000, and one item of this expenditure arose from the employment of eight men kept for the purpose of repairing the tarpaulings. The writer believes he is perfectly correct in stating, upon the same authority, the use of tarpaulings to have been a charge of 4d. per ton upon the goods.

The tarpaulings were certainly extensively used in the inland navigation of the Canals, to protect the contents of the boats from water, but the same means has been employed, with strange inconsistency, to protect the goods carried by Railway from fire. The costliness of tarpaulings may be inferred from the fact, that to some large Companies the annual expenditure for them is about £12,000, exclusive of all the other expensive contingencies inseparable from their use. In wet weather, the writer has seen as many as three tarpaulings used in covering the contents of a single Waggon, and even these have failed to keep dry the merchandise. This arises from the great number of small holes which are daily made in them, from some sharp point or angle of a package cutting them through. So uncertain is the probable duration of a tarpauling, that a new one is sometimes spoiled the first day of its employment; each tarpauling costing from £4 to £6.

It is evident that an open truck is a box without a lid, whether it be made of crib-rails or deal-board sides and ends. Over this a tarpauling is thrown by three or four men, who attempt to secure it, by pieces of rope provided for the purpose, to the hooks or rings attached to the Waggon, but it often happens that the trucks are not filled to a level with the top side of the Waggon; the consequence is, that when heavy rains fall, the weight of the water collected on the top of the tarpauling is so great, as to invert it in the centre, making a pond or dished cistern, of about nine inches deep, or more, containing many gallons of water.

The Goods Manager of one of the great lines informed the writer, that in the wet season he has employed as many as twenty men to throw off the water collected on the tops of the tarpaulings, and tighten them on the road, at one station only; but that on their arrival at London they were again in the same state: this was

when the tarpaulings were sound. In those cases where they were not water-tight, the damage done was serious; tea, sugar, cheese, silks, and indeed all other goods were more or less damaged, entailing complaints from the public, and much loss to the Companies.

Those princely merchants, the East-India Company, have shown much more tact and prudence, in the employment of a large covered portable warehouse on wheels, perfectly secure from any contingency whatever; to have employed an open cart and tarpauling, for the removal of the treasures of the East from the docks to their warehouses, would have been a parallel to the open Railway Waggon, and as costly.

The various drawings will convey some idea of the progressive nature and date of the changes in construction of Railway Waggon stock. The success and extent of these improvements may be inferred from the fact that, ten years since, the stock of one great Railway Company was only one fifth of its present number, and the money receipts about one sixth, yet the annual cost for maintenance is now not double the amount it was at the period referred to.

The attention of the writer was forcibly called to the immense loss, arising from the destruction of property—occurring whenever an accident took place—not only from damage done to the goods in the open Waggons broken up, but also much more from goods thrown out of the same, when off the line; the ordinary open Waggon being no better than a box or basket without a cover, from which is ejected the whole of its contents when the Waggon is turned over; and this has sometimes been upon the rails—into a field—a ditch—down an embankment—or into a canal.

These evils were often the subject of remark, and finding that no one attempted to improve the system, the writer determined to make an effort, which has resulted in the New Covered Goods Waggon, shown in Fig. 2, Plate 36, and of which a model is before the meeting. This subject is brought forward for the purpose of calling attention to the remarkable contrast which has been practically found by experience to result from the use of the

New Covered Waggon, or Transit Warehouse, as compared with the open waggon.

Accidents to trains containing the New Covered Waggons have happened; some of them have been thrown to the bottom of steep embankments, and others forty feet from the rails, into a field, and in fact exposed to all the violence of collisions taking place with trains consisting of seventy Waggons, travelling from twenty to thirty miles an hour, and loaded on an average with 3½ tons each, the gross weight in motion being about 490 tons; and in all cases, and under the most difficult circumstances, the contents of the Covered Waggons have been preserved, in most instances, from any damage whatever, while the waggons themselves, from the peculiarity of their construction, have sustained so little damage as to have excited particular notice. A case recently occurred of two of these being thrown off the rails, while the train was at full speed, containing 4½ tons of goods each, which were not at all damaged, neither was the square of the waggons found to have been broken.

In the year 1830, the speed of passenger trains was under twenty miles per hour, but at this period the speed of goods trains reaches from twenty to thirty miles an hour, with a degree of safety not at all second to the passenger trains: therefore, the sound construction formerly necessary for passenger carriages became fully needed by the present requirements of the traffic for the goods Waggons.

The construction of the New Covered Goods Waggon is adapted to meet this demand. By a well-considered and scientific employment of wood and iron, perfect rigidity has been obtained in all parts of the superstructure of the Waggon, which has the effect of permitting the utmost freedom in the mechanical parts intended to move, and thereby greatly to facilitate its following the engine. The New Covered Waggon, while it actually costs less, first cost excepted, performs the important service of running more miles, and earning a larger sum of money, free from all claims for damage, than any other Waggon in use. It is in more favour with the carriers and the public, and is consequently more employed; and it is acknowledged to be so little affected in

requiring repair as to have excited attention. It was remarked a few days since, that the Covered Waggons were rarely out of order; in fact, only through accidents, and repairs caused thereby, grease and wheel-turning being the chief charges against them.

It will be observed in the section shown in Fig. 4, Plate 37, that the side door-posts of the Waggon, the opening for the admission of goods, the slide, roof, ribs, waterway, and door-beads, are examples of a combination of wood and iron of much value. The doors, slide, and waterways, although in continual use for five years, have not cost two shillings each for repairs; neither has a single door-post been broken, or in any way damaged.

An important feature in the New Covered Waggon is, having obtained a perfectly even and smooth interior of the sides and ends of the body, or loading space, which is nearly 600 cubic feet, being almost double that of the ordinary open goods truck. The practical value of this improved surface has most effectually benefited the public, the carriers, and the Companies; whereby a cause of great complaint, expense, and trouble, has been removed. The cases of damage done to bales of goods, by chafing against the uneven surfaces of the bolts and rivet-heads of the open Waggons, has been reduced to one in a thousand cases of those constantly occurring before. The entire build of the Waggon is so contrived, that when once closed it cannot be entered or taken to pieces, even by the workman who has constructed it, without first obtaining access to the interior, the whole of the superstructure being fastened from the inside; a lock and bolt of great simplicity are secured on the same principle. One man can open and securely close the New Waggon, while several men are required to put the tarpauling on the open Waggon.

The inflammable nature of the coverings used for Open Waggons greatly increases the risk of fire, from cinders falling upon them from the Engine, and which would happen daily but for the fortunate circumstance of the wind seldom blowing in a direct line with the progress of the train. But for this mere accident, trains taking fire would be daily occurrences.

The Covered Waggon also affords the most remarkable protection to other Waggons from being ignited by their proximity to any that may be on fire in the train. Instances have happened on several lines of Railway, property where in Open Waggons, as well as the trucks themselves, have been destroyed. The New Covered Waggon, if in a train of ordinary Waggons on fire, will effectually cut off the progress of the flames from being extended to the next tarpauling, and consequently to the open Waggon and its contents. Several instances of the New Waggons rendering this service have arisen. One of them contained some thousand pounds' worth of silk, and in the words of the official report, the contents were not damaged, while the Waggon itself was merely charred, and the paint blistered at the end next the fire, which was raging while the train was drawn into the nearest station. In fact, fire occurring in open Waggons spreads rapidly; the flames being very forcibly driven backwards by the speed of the train, will fire all the Waggons behind, if covered with tarpaulings, or open, but they are effectually stopped by the Covered Waggon checking the progress of the flame back.

The liability to fire is only one of the many objections to the tarpauling covering; it is very liable to be blown about, and sometimes off, exposing the contents of the Waggon to every contingency.

The perfect security now obtained in the transit of the goods in the Covered Waggons has caused the ordinary insurance of one pound per ton for silk to be discontinued, as also an allowance formerly made to the men for extra care of the goods previously conveyed in open Waggons. The object of the writer has been, to avoid every known defect of the open Waggons, and gradually, as far as practicable, to remove the immediate causes of damage to goods, loss of waggon service, and to reduce repairs as nearly as possible to grease and wheels, and so to improve the construction generally, as to adapt it to the varied, but well-defined requirements of the Railway system. The absence of all claim for damage done to property, carried in the New Waggon, is a fact that proves some success has attended these efforts.

Further proof of the value of the Covered Waggon may be inferred from the fact, that the carriers consider their work to be half done, when once the goods are deposited in the Improved New Covered Waggon, as compared with the serious responsibility of sending the goods in an open Waggon. The carriers stated to the writer that great anxiety is felt until the time has passed for the arrival of the open Waggon at its destination, and the delivery of one post; and it is only on the non-arrival of complaint at the period referred to, that the carriers begin to feel secure from any claim for damage. The Corresponding Clerk of one large establishment also reports that he is at a loss to name an amount for the unmistakeable saving effected in correspondence, since the Covered Waggons were first introduced; and more especially as the traffic has increased to an extent not anticipated by the most sanguine. The goods deposited in a Covered Waggon invariably arrive in precisely the same state as when loaded, free from wet, &c. Some thousands of letters less have come to hand in reference to goods lost and damaged by conveyance in open Waggons.

Even with what used to be considered the *ne plus ultra* of the Open Waggon plan, (Fig. 1, Plate 36,) with that great step in improvement—permanent wood sides and ends—little more security is effected than by crib-rails. This plan can hardly be said to have been subjected to the rule of science at all; it merely consists of certain parts of wood and iron, most unskilfully proportioned to construct a Railway Waggon, the sides and ends forming the superstructure being boards merely laid horizontally edge to edge, and the standards bolted across the face of the boards, at right angles; leaving all free to work, like so many parallel joints. The effect of this mode of building is, that the whole of the parts soon become loose, and, quite as much as the traffic, accelerate the destruction of the Waggon.

Another cause of serious expense, attached almost exclusively to the Open Waggons, is the great danger and outlay incurred by the defective state of the floors, which are found to decay rapidly, the consequence of continual exposure to the different effects of

summer and winter. No attention had been directed to the importance of constructing Waggon stock to remove this serious defect, until the writer gave it his consideration. He has seen hundreds of the open goods and cattle waggons standing, in winter, with two inches depth of manure and water covering the entire area of the floor, in which holes have afterwards been made to let out the water. One of the greatest practical evils resulting from rotten floors is, the great facility with which the legs of the cattle have slipped through and been broken. The trains have in some instances been thrown from the line, causing much delay and expense. In one or two cases, the beast fell completely through the bottom of the Waggon upon the line, whereby the traffic was interrupted, and much damage done. Open merchandise Waggons would be the source of many more accidents and greater expense, but for the vigilance of experienced and attentive local examiners of the trains, at the stations on the road. The constant expense caused by the exposure of the Open Waggons to the deteriorating influence of the weather, whether in or out of use, is most serious in amount, as there are several millions' worth of waggon property undergoing depreciation from this cause, for which the Companies have to pay a tax equal in amount to that for the employment of the work.

The result of many years' experience has shown that doors at the end of a waggon are a source of great expense for maintenance, as the ends are subjected to by far the greatest portion of the work, from the violent strains in starting and stopping; and the end doors also cause much inconvenience in working at the stations. The adoption of side-doors was, however, considered objectionable, because the sides of the waggon were then cut completely in two, and rendered weak; but this objection has been got over in the New Roofed Waggon, in which the sides are fully as strong as the rest. The side sliding doors of the New Waggon are always free to move, as well as the moveable portion of the roof, by which valuable provision, the crane chain can deposit or remove a bale of goods, however heavy, from any part of the interior of the Waggon.

(See Cross Section, Fig. 4, Plate 37.) Indeed, such is the ease with which the operations of loading and unloading can be performed, that the carriers report that the goods almost tumble in and out of the Covered Waggon, when the steam crane is used; at once removing all doubt, if any were entertained, about the great saving of labour, and absence of all inconvenience, attending the use of the New Waggon. In the words of the carriers' report, "no one can properly estimate the saving effected in property and time by the employment of the Covered Waggon."

In addition to the serious disadvantages of the old open plan of Waggons, with which property to a large amount is either stolen, burnt, or damaged by water and other means, there is yet another remarkable circumstance, that has not been adverted to. Some Waggons contain meat instead of merchandise, and then they not unfrequently become a travelling cooking apparatus, in which cargoes of whole sheep and pigs are roasted, but, what is much more unsatisfactory, spoiled also. The New Waggon is not only proof against fire happening to its contents from external causes, but is almost so in reference to its own construction. One of the plans generally adopted, is an entire outside skeleton of wood framing, well secured in all its parts by suitable ironwork, the inside of which is lined with sheet-iron plates, of No. 16 gauge, which are fixed by screws to the wood scantling. The under side of each plate is bedded upon strips of felt, laid upon the inside of the wood standards, three inches wide. The plates form a flush butt joint with each other, having a surface bearing of 1½ in. against the framing of the body, thereby securing a perfectly even and smooth surface of iron over the entire area of the loading space. This evenness secures the packages from damage by chafing, and effects great durability and rigidity in the superstructure of the Waggon, and consequently great reduction of cost for repair.

Fig. 7 explains the plan of constructing the roofs, which are also made of No. 16 gauge sheet iron, laid upon bent ash ribs, 3×1¾ inches, on the top surface of which are placed strips of tarred felt, 2¾ inches wide, upon which each sheet of iron has a surface

bearing of 1¼ inch, and is secured to the rib by screws. It should be observed, that the plates intended to form the roof are so laid as to leave a space of ¼ inch between the edges of each, for the purpose of allowing a screw to pass between the edge of each plate. This space, and the upper surface of each sheet of iron, are, in like manner to the under side, covered by a strip of felt, 2¼ inches wide, upon which is laid transversely a piece of hoop iron of the same width, and this is made to cover the two rows of screws by which the iron roof-plates are made fast to the wood ribs, and is itself secured by a single row of screws passing between the edges of the plates forming the roof. The cost for maintenance of roofs so constructed is merely nominal, no case of repair having yet happened (accidents excepted) in five years, while the certain cost of tarpaulings for 500 Waggons during that period, would not be less than £7,500.

The section of the slide roof and waterways, shown in Fig. 6, Plate 37, will explain the construction of that important part of the New Covered Waggon. It will be seen that the moveable portion of the roof runs upon rollers of chilled cast iron, accurately turned, and revolving on a steel axle, to prevent wear. The waterway and roller path is partly covered with a flat strip of iron, on which the rollers freely work, and move the slide roof. The plate of iron, A, answers the purpose of strengthening the wood rib, B, and effectually prevents any water getting into the interior of the waggon; its surface is also useful for the crane chain to work against, and thereby protects the wood from injury. The whole of the space for the admission of goods is in like manner faced with iron, which renders repair of this part of the Waggon most trifling. By this mode of construction, the dimensions of the door opening and its respective working parts are accurately preserved; consequently, the doors and slide are always found to move easily. The slide, C, is most effectually prevented from removal for improper purposes, by the external rib, D, and the iron top plate, secured by a bolt, E, and nut, on the inside of the sheet-iron roofing.

Fig. 5 shows a full-sized section of the doors, side waterway, and roller path in which they work; and of the inside casing by

which, when out of use, the doors are protected. It also shows the level of the floor-line and door-post, faced with bevelled iron plate, forming also a snap bolt and nut. All these parts of the Waggon have so perfectly answered the purpose for which they were designed, that after six years' use, the writer is not aware of any alteration that can be made with advantage to the plan.

Fig. 3, Plate 36, represents a Covered Waggon of similar construction to that which has been explained above, with this difference, that the doors on both sides, and the corresponding part of roof, are framed together, and move longitudinally either to the right or left, as may be desired.

Plate 38 represents sections of four other plans of moving roofs: Fig. 8 being suitable for a goods Waggon where sliding doors on each side are requisite, and is formed of two slides, A A, moving transversely upon the Waggon, one above the other. This plan of Waggon is in all other respects constructed in the same manner as the one shown in Fig. 2.

Fig. 9 is a section showing a roof, with the slide, A, running longitudinally in grooves upon the top of the Waggon, and applicable to such as have doors at the end.

Fig. 10 is on the same principle, with the exception that the slide, A, moves upon an iron rod, B, secured on each side of the roof, the moving portion of which is kept in its place by eye-bolts, through which the rods pass.

Fig. 11 is a part elevation of another plan of roof, by which the sides, A A, move longitudinally to the right and left. This arrangement is suited to Waggons that are required to have folding doors on each side.

All of these plans have been for some time practically in use, with advantage.

There are several modifications of the plan of building these improved Waggons, but the one shown in Fig 2, and another in which deal boards are used, instead of the iron plates, to form the body, as before described, are those generally adopted. The roof is in all cases formed of sheet-iron, painted.

The subject of dead weight, as compared with the load carried is of importance.

The original Waggons weighed from 2 to 2¾ tons; load, about the same.

The present Open Waggons, Fig. 1, weigh 3½ tons: load, 4½ tons; being 1 ton in favour of paying weight.

The New Covered Waggons, Fig. 2, weigh 3½ to 5 tons. A few only, with iron floors, heavy axle-boxes and wheels, weigh 5 tons; the general class weigh 4 tons, carrying 6 to 8 tons.

The exact weight of the present build would be 3½ tons: load, 6½ tons. Paying weight, as compared with dead weight, 3 tons gained. The general class of low-sided Waggons weigh from 2½ to 4 tons, carrying 2½ to 4½ tons. The general class of high-sided Waggons weigh from 2¾ tons to 4 tons 2 cwt.: load, 3½ to 4½ tons.

In concluding this paper, the writer will refer to a few of the items in which a saving has been permanently effected. He more particularly wishes to remark, that in the removal, by the Covered Waggons, of many old and expensive sources of repair, common to the open Waggon, he certainly has not introduced any new ones in connection with the improved plan of Waggon, the construction of which will so much lessen repair, that the reduced expenditure, as compared with the ordinary open Waggon, will in time provide a fund sufficient to reproduce the Waggon; saving the necessity of laying by money to meet any loss arising from depreciation.

The cost of maintenance of the open Waggon stock varies from 7 to 10 per cent. on the first cost of the same. The repairs of the Improved Waggon do not exceed 4 per cent. on the prime cost. Difference in favour of the New Covered Waggon, about one half.

The cost for tarpaulings to cover the open Waggon is reported in some instances to be so moderate, and in others so high, as to leave some doubt upon the subject. That it is most serious, all are aware. The writer, who has paid some attention to this subject, is prepared to prove that the charge cannot be less than 6 per cent. on the cost of the open Waggon. The whole of the charge for tarpaulings is saved by, and is therefore in favour of,

the Covered Waggon. The annual cost for tarpaulings, to one large Company alone, is £12,000.

The open Waggons are further chargeable with most serious items arising from damage done to goods by water, loss by pilferage—in some years hundreds, and as often thousands of pounds; also destruction of property by fire, to such an amount, that it is serious even to a Railway Company; and claims for compensation, arising from causes too numerous to be more than adverted to.

The use of the Covered Waggon may be said to be free from this catalogue of charges; to which may be fairly added the fact, that while the improved Waggon costs less, as shown in every way, it actually gains a larger sum of money than the open Waggon, by being more constantly in condition to work, and secures its earnings free from the deductions referred to.

The cost of these Improved Covered Waggons does not now exceed the price formerly paid for the old open Waggons.

Mr. Henson exhibited a complete working model of his improved covered waggon; he said it possessed as great a capacity for loading as the ordinary goods waggons, and was quite as strong, if not stronger.

Mr. Slate inquired, how often the new waggon could be loaded, in regular traffic, with goods to the amount of seven or eight tons; and what description of goods was intended to be carried by it; and what weight of light or damageable goods it would hold?

Mr. Henson replied, that the waggon would take to the amount of from five to seven tons of sugar, silks, &c., and other damageable goods. It was calculated for the conveyance of Manchester goods, which were generally heavy; and

these waggons were found by the carriers particularly serviceable in carrying, with perfect security, these descriptions of damageable goods. Sheet and hoop iron also would load them to seven tons; and these goods required substantial covering, to protect them from rust and other injuries; and serious loss was sometimes experienced from the damage caused to them by exposure to the weather in the ordinary open waggons.

Mr. Slate observed, that in Mr. Henson's waggon the reduction of the tare was certainly very considerable; it appeared he had produced a vehicle which, for every ton of its own weight, would carry double the weight of goods. This was a great step in the right direction, and he hoped the waggon might be further enlarged and improved—even to double its size—that expenses might be saved, and a reduction in the carriage of heavy goods be effected.

Mr. Henson replied, that the great objection to any extension of the length of the waggons, was the manner in which they were now confined by the station buildings, the approaches to the warehouses, and the turn-tables. Great alterations would be required at the stations, along the whole line of railway, before any enlargement of the present size of waggons could take place.

Mr. W. Smith said, it was clear that the waggon possessed every facility for loading all kinds of goods; and it had been shown, in various ways, that the ordinary open waggons and tarpaulings were very imperfect and expensive. He saw that certain parts of the new waggon were made of corrugated iron; and he wished to inquire where the extra strength and saving in weight were obtained; and why the framing and the platform were not also made of iron, instead of wood?

Mr. Henson explained, that he considered the combination of wood and iron that he had adopted was decidedly the best. In his opinion, an entire iron waggon would not only be heavier, but it would be weaker, while, at the same time, it would be considerably more expensive, and more difficult to

repair. The wood prevented the iron from bending, and the iron prevented the wood from breaking; and by these means a great increase of strength was obtained.

The CHAIRMAN remarked, that this question of construction had been discussed upon a former occasion, after a paper read by Mr. Adams; and the relative merits and strength of iron and wood, as used separately or combinedly in the construction of railway carriages, was an important subject for consideration: it had been recommended to make the under frame of iron.

Mr. W. SMITH suggested, that the waggons should have iron sides and ends entirely, as well as iron tops, if the object were to protect the goods against the effects of fire, as protection was quite as necessary in that part of the carriage, when a train was on fire, as it was on the roof.

The CHAIRMAN observed, that he could bear testimony to the new waggon being an effective security against fire. In his own experience, he had known it operate, when placed between two of the old waggons, as a complete check against the progress of fire in a goods train on the railway.

Mr. SLATE, referring to the model of the new waggon, showed the great additional strength which the roof, from its construction, gave to the body of the waggon, as compared to an open waggon. The frame acted as diagonal bracing; while the roof, like the deck of a ship, strengthened the general structure of the vehicle.

Mr. COWPER observed, that the roof of the waggon made the whole body, as regarded strength, into a complete girder, of the full depth of the waggon.

Mr. ADAMS quite agreed with Mr. Henson, with regard to the objection to iron for the upper framing; there would be great difficulty in riveting corrugated iron to iron framing, and such a process would necessarily lead to considerable expense; but it was comparatively easy to fix the corrugated iron by screws to wood framing. He was of opinion, however, that iron was better for the under framing than wood. He considered

that the waggon, as constructed, was very safe from fire; and if, with a dead-weight of only 3½ tons, it could carry 6 or 7 tons of goods, it was most unquestionably a very efficient vehicle.

The CHAIRMAN said, the protection against fire went far to show the superiority of Mr. Henson's waggon; and when they considered the great losses to which Railway Companies were subjected, by damage done to goods entrusted to them for conveyance, it was evident that great advantages were derivable from efficient protection, by having the waggons completely closed, and as nearly as possible air-tight. It would also be a great saving to Railway Companies, in reducing the proportion of the dead-weight of the waggons, as compared to the paying weight carried; and in addition to the protection from injury and loss, the expense of goods conveyance would be considerably reduced, and the means of carriage increased. He proposed a vote of thanks to Mr. Henson, for his paper, which was passed.

The following paper, by Mr. C. W. SIEMENS, of Birmingham, was then read:—

ON A NEW REGENERATIVE CONDENSER FOR HIGH-PRESSURE AND LOW-PRESSURE STEAM ENGINES.

THE Condenser of a Steam Engine has for its object the complete discharge of steam from within the working cylinder, after it has served to propel the piston. This is effected by conducting the expended steam into a closed chamber, containing an extended surface, of comparatively cool substance, which absorbs the latent heat of the steam, and thereby reduces it to its liquid state. Cold water is generally employed for this purpose, which is either brought into immediate contact with the steam, as is the case in Watt's Injection Condenser, or through the medium of metallic walls, as in the Surface Condenser by Hornblower, improved upon by Hall and others.

The more or less perfect condensation of the steam depends—

1st.—On the absence of air from the Condenser.

2nd.—On the temperature at which condensation takes place.

The appended Table shows the elastic force of steam in vapour, at various temperatures. It will be observed that, in order to produce a perfect vacuum, the water should leave the Condenser at about 32° Fah., or be introduced in the form of ice. Condensing water, however, is generally obtained at the temperature of about 60° Fah., and it leaves the Condenser at about 110° Fah., which latter temperature implies a remaining atmosphere of vapour equal to 2.5 inches of mercury, or in other words a vacuum of 27·5 inches below the atmospheric pressure at 30 inches. If a less quantity of condensing water be used, it will be raised to a proportionately higher temperature, and a less perfect condensation be effected. At 212° Fah., the pressure of the uncondensed vapour would be equal to that of the atmosphere, and the object of the Condenser would be entirely frustrated.

In all cases where an abundant supply of condensing water cannot be obtained, or where the heat of the steam employed by the Engine is reclaimed for other purposes, Steam Engines are worked without a Condensing Apparatus (or at high pressure) at the sacrifice of an effective pressure nearly equal to that of the atmosphere upon the working piston. The *Regenerative Condenser* (the subject of the present paper) redeems the Engine from this waste of heat in the one case, and loss of mechanical effect in the other case, being possessed of the peculiar property of returning the condensing and condensed water at the initial temperature of the steam previous to its discharge from the working cylinder, (commonly speaking, at 212° Fah.,) effecting nevertheless an efficient vacuum.

Fig. 1, Plate 39, shows a sectional elevation of the Regenerative Condenser, as applied to a 10HP high-pressure Engine. It consists of an upright rectangular trunk of cast iron, A, the lower end of which, B, is cylindrical, and contains a working piston. The trunk is filled with metallic plates, which are placed upright, and parallel to each other, with intervening spaces of not less than $\frac{1}{16}$th of an inch in breadth. The upper extremity of the Condenser communicates on one side, E, to the exhaust-port of the Engine; and on the other, to the hot-well, F, through a valve, G. A stop, H, prevents the opening of the valve

beyond a certain distance, in order that it may re-shut more instantaneously. The metallic plates D, are fastened together by five or more thin bolts, with small washers between the adjacent plates, which keep them the required distance apart. They can easily be removed from the Condenser, for the purpose of cleaning, by taking off the cover, I, and drawing out the whole of the plates.

An injection pipe, K, enters the Condenser immediately below the plates; it is provided with a small air-vessel, L, and a regulating cock.

The action of the Condenser is as follows:—

Motion is given to its working piston by the Engine, causing it to accomplish two strokes for every one of the Engine.

At the moment when the exhaust-port of the Engine opens, the plates, D, are completely immersed in water, a small portion of which has entered the passage above the plates at A, and is, together with the air present, carried off by the rush of steam through the valve, G, into the hot-well, where the water remains, while the excess of steam proceeds into the atmosphere. An instant after the partial discharge of the steam cylinder has commenced, the water recedes between the plates, D, and exposes them gradually to the steam, which condenses on them in the manner following. The upper edges of the plates, emerging first from the receding water, are enveloped in steam of atmospheric pressure, and in condensing a portion thereof, they become rapidly heated to nearly the temperature of the steam, or about 210° Fah. The partial condensation diminishes the density and temperature of the remaining steam, which requires additional and cooler surfaces for its further condensation. This is provided for by the continual emerging of additional portions of the metallic surfaces from the water. By the time the water-level leaves the plates, the far greater portion of the steam is condensed. The condensation of the remaining portion of steam could not so readily be accomplished by means of metallic surfaces, but the piston, C, continuing to descend, puts it into immediate contact with the jet of cold water from the pipe, K, which completes the vacuum in the manner of a common Injection Con-

denser. The air-vessel, L, connected with the injection pipe, has the effect of accumulating the injection water, at the time when the water has ascended between the plates, and of forcing it into the Condenser with increased intensity, at the time when it is required to complete the vacuum.

Although the action of this Condenser is strictly consecutive, yet it does not check the continuous flow of steam from the cylinder, and it completes the vacuum when the working piston of the Engine has only accomplished one tenth part of its stroke. Both the engine-crank and the crank driving the Condenser are on the top centre at the same moment, but the latter completes its revolution in the time of half a revolution of the Engine; consequently, when the engine-piston has passed only one-tenth of the whole stroke, the condenser-crank will have travelled through nearly half its stroke, when the whole process of condensation will have been completed. The principal part of the latent heat of the steam is stored up in the plates, the upper extremities of which are heated to 210° Fah., and the lower, to about 150° Fah.

The water, in re-ascending between the plates during the last tenth part of the stroke, absorbs heat therefrom in a similar successive manner, passing first the coolest, and by degrees the hottest portions of their surfaces, and issues finally into the upper steam passage, at a temperature approaching the boiling point, at which moment a fresh discharge of steam takes place, which carries it off into the hot-well, as above described, and raises its temperature fully to the boiling point.

Fig, 3, Plate 40, represents an actual indicator diagram, showing the time occupied in completing the vacuum; but it will be observed, that the loss of time and power may be decreased by increasing the capacity of the displacing cylinder; but, as it is, this loss does not amount to one seventh part of an uniform vacuum, an equivalent for which is obtained in the saving of the power hitherto absorbed by the air-pump; for it will be observed, that the displacing piston works between two vacuums, and therefore meets with no resisting load.

Various modes have been provided to give motion to the dis-

placing cylinder; among which a knee motion, worked directly from the beam or cross-head of the engine, is generally found the most convenient, as shown at M M in Fig. 1.

The quantity of condensing water required with this Condenser to condense one pound of steam, of atmospheric pressure—taking the initial temperature of condensing water at 60° Fah., the final temperature at 210° Fah., the latent heat of steam of 212° Fah. at 960 units—is

$$\frac{960}{210-60} = 6{\cdot}6 \text{ lbs.}$$

of water to condense 1 lb. of steam.

The common Injection Condenser (supposing the condensing and condensed water to issue at 110° Fah.) requires

$$\frac{960+(212-110)}{110-60} = 21{\cdot}2 \text{ lbs.}$$

in place of the 6.6 lbs. which the Regenerative Condenser requires. In the case of a locomotive, or other high-pressure Engines, where the steam is released from the cylinder at a pressure of, say 30 lbs. above the pressure of the atmosphere, two thirds would be allowed to escape uncondensed, and a vacuum be obtained with only $\frac{\cdot 66}{3} = 2.2$ lbs. of condensing water for every 1 lb. of steam passed through the cylinder.

The small quantity of condensing water required, renders the proposed Condenser applicable to Engines in nearly every locality; and pains have been taken to render the apparatus itself equally light and compact. The advantages resulting from its application to high-pressure Engines are as follows:—

1. Additional effective power, gained on account of the vacuum.

Fig. 3, illustrates this gain, which (supposing the average steam pressure to be = 40 lbs. above the atmosphere, and vacuum within the cylinder = 10 lbs.) amounts to 20 per cent, irrespective of expansion. If both the steam pressure and the duty on the Engine remain unchanged after the Condenser is applied, it is evident that the steam may be worked expansively to a large extent, without diminishing the absolute driving power of the Engine.

2. Heat saved in generating the steam, by the use of *boiling-hot feed water;* and the remaining portion of hot water may be advantageously used for heating buildings, dyeing, &c.

High-pressure Engines are frequently provided with heating apparatus for the feed water, which heats it on the average to about the temperature of the condensing water from low-pressure Engines, or 110° Fah. The proposed Condenser heats it to 210° Fah., which constitutes a saving of $\frac{210-110}{960}$ = about 10 per cent.

When such heating apparatus is not provided, the saving amounts to $\frac{210-60}{960}$ = about 15 per cent.

3. The steam which is not condensed may be used to cause a draught in the chimney, or for other purposes.

4. The displacing cylinder, unlike the air-pump of the Injection Condenser, abstracts no motive power from the Engine.

5. The Condenser may be started and stopped at any time, by turning the supply of injection water either on or off. If turned on, it at once forms the vacuum, without involving the necessity of blowing through; and if turned off, it allows the Engine to proceed in the same manner as though no Condenser had been applied.

6. The air contained in the Condenser is, at the commencement of each stroke, *bodily expelled*, which is of great advantage to the formation of a good vacuum, instead of the ordinary air-pump removing only a portion of the air at each stroke, and consequently leaving a portion always in the Condenser.

7. The Regenerative Condenser is more compact, and even less expensive than the ordinary Injection Condenser, being less than one quarter of the size, and having only one valve instead of three.

Its proportionate dimensions are as follow:—Area of plate-chamber, three times the area of exhaust-pipe; length of plates, one quarter to one third part of length of stroke of engine; thickness of plates, $\frac{1}{292}$nd part of this length. Spaces between the plates, the same, but never less than $\frac{1}{16}$th of an inch, it having

been found that the alternate rush of water and condensing steam prevents the settlement of grease and earthy matter between the plates, if they are not less than $\frac{1}{16}$th of an inch apart. Capacity of displacing cylinder, equal to one and a half times the capacity of the plate-chamber. The total capacity of the Condenser is only equal to about the tenth part of the capacity of the working cylinder. In applying the Regenerative Condenser to existing high-pressure Engines, a saving of fuel of from 30 to 35 per cent. has been effected, or an increase of power to that amount with the same expenditure of fuel as theretofore. This saving may however be still considerably augmented, if advantage be taken of the increased effective pressure to work the engine expansively. This may in most cases be easily effected, by merely adding to the lap of the slide valve, and increasing the lead of the eccentric proportionately, whereby the additional advantage of a more early discharge of the steam is obtained.

The advantages attending the application of the Regenerative Condenser to stationary Engines being practically proved, the author is desirous to extend the same also to that important class, the Locomotive Engine. In inviting the attention of Railway Engineers to this inquiry, he is prepared for practical objections being raised, on account of the great rapidity of motion, the necessity for the greatest possible simplicity and lightness, the deficiency of condensing water, &c.; but he thinks that the Condenser under consideration is peculiarly well adapted to meet these objections.

Its peculiarities in this respect are:—That it may be accommodated to any speed of piston, by reducing the length and increasing the breadth of plates, thus reducing the velocity of the displacing piston proportionately.

Its dimensions are proportionate to the capacity of cylinder only, and not (like other Condensers) to the horse-power of the Engine.

The total weight of a pair of Condensers, as applied to a locomotive Engine with cylinders of 13 inches diameter and 20 inches stroke, is about 3½ cwt.

The power of the blast remains nearly undiminished.

The Condenser requires no attention in working the Engine, and in case it should fail to act, from any accidental cause, the Engine will continue to work high-pressure as usual; moreover, it does not interfere with the working parts of the Engine.

The advantages which would result from a vacuum in the cylinder of a Locomotive Engine, have been ably set forth by Mr. Edward Woods, in his "Observations on the Consumption of Fuel and Evaporation of Water in Locomotive and other Steam Engines."—The present paper may therefore be limited to the means proposed for that purpose.

The two Condensers are cast in one piece, and placed immediately in front of the cylinders of the Engine. Each of them closely resembles the Condensers above described; only the length of the plates, and the stroke of the displacing pistons, are much reduced in proportion to the steam cylinder, in order that the velocity of the water between the plates may not exceed certain limits.

The two displacing pistons are connected to opposite ends of a short vibrating beam, which receives its motion from the Engine.

In addition to the exhaust valves leading into the hot-well, these Condensers are provided with a second set of discharge valves, of a somewhat peculiar construction, which, with very limited motion, combine the advantage of opening a perfectly clear passage for the exhaust steam of the Engine into the chimney, where its remaining expansive force is required to produce draught. This valve consists of a longitudinal rectangular slot, in the upper wall of the steam passage which leads from the Cylinder to the Condenser.—At the ends of the slots are triangular pieces, which support the sides of two longitudinal lips which cover the aperture, except at such times when a superior pressure from within forces them open. The extent of their motion is limited by dead stops.

The escape of steam, together with the hot water, into the hot-well, is regulated by a blow-off valve from the latter into the atmosphere; by this means a pressure above that of the atmosphere is obtained in the hot-well, which acts favourably in forcing the boiling-hot condensing water into the feed pump of the boiler.

It has been stated above, that the ordinary supply of feed water is of itself not quite half sufficient to maintain a vacuum within the Condenser, and an additional supply of water must be provided for. Considering, however, the smallness of the excess of condensing water, especially if the diameters of the working cylinders are reduced in proportion to the additional effective power gained, and considering that boiling-hot water will readily part with the principal portion of its heat, it is proposed to take it back to the tender through a simple Refrigerator, in which advantage is taken of the rapid motion of the Engine through the air for cooling the water. The Refrigerator may be placed conveniently on the back of the tender.

The application of the proposed Condenser to low-pressure Engines (see Fig. 2, plate 39,) requires but a short notice, after what has been said already; the letters refer to the same parts as in the former description of the High-Pressure Condenser, shown in Fig. 1. In it the steam, at the time when it is released from the cylinder, has not sufficient force to expel the air and heated water from the Condenser into the atmosphere, and a partially vacuous space must be provided for their reception. For this purpose, that side, B, of the displacing cylinder which, in the arrangement hitherto described, is always empty, is put in communication with the exhaust valve, G, of the Condenser, and receives the charge of water and air at the time when the piston is at the opposite end. A second valve, O, is provided, through which the water is expelled into the hot-well during the return of the piston. For the convenience of arrangement, the displacing cylinder is reversed.

The chief advantages obtained by the application of this Condenser to the low-pressure Engine are:—

1. The requisite amount of injection water is reduced in the proportion of 3 to 1.

2. The feed water of the boiler is obtained nearly boiling hot' which constitutes a saving in fuel of $\frac{210-110}{1960}$ about 10 per cent.

3. The whole amount of heat generated under the boiler is given off by the Engine in the form of water, at 210° Fah., which,

in most cases, may be advantageously employed for heating buildings, for washing, dyeing, and other purposes.

4. A large proportion of the power required for working the air-pump is saved.

The first Regenerative Condenser was attached to a 16-HP high-pressure Engine, at Saltley Works, near Birmingham, in September, 1849, where it has been found to answer, although it is not perfect in its proportions, and could not be kept constantly in operation, in consequence of a deficiency of injection water. The actual indicator diagram, shown in Fig. 3, Plate 30, was taken from this Engine; since then, several more have been erected, and the result above referred to obtained. The *dotted line* in Fig. 3, shows the indicator diagram taken from the Engine before the Condenser was applied, and the *full line* shows the diagram of the Engine working with the Condenser, and exerting exactly the same power as in the former case. The *shaded portion* of the diagram shows the power gained or saved by the use of the Condenser.

The author proposes to conclude this paper with a short historic sketch of the Steam Engine Condenser, to illustrate the distinct features of this proposed system.

In Newcomen's Engine, the condensation of the steam was effected by the alternate introduction of a jet of cold water into the steam cylinder itself. The cold water naturally cooled the walls of the cylinder, which in their turn condensed a large portion of the succeeding charge of steam before it had forced the piston upward.

James Watt, in seeking a remedy against this loss of heat, conceived the possibility of condensing the steam in a separate closed vessel; and in carrying his idea into effect, he not only realised his immediate object, but at the same time rendered the Steam Engine susceptible of that degree of perfection and general application of which it is now possessed. The Injection Condenser of Watt is the most effectual of its kind, and has maintained its exclusive dominion to the present day. It consists of a closed vessel, which communicates periodically with the steam cylinder. The injection water, together with the condensed

metal, and with its thickness; but the conducting power of copper is so great, that its thickness seems to exercise no appreciable influence on the amount of heat transmitted in a given time. This interesting fact is proved by Dr. Ure's experiment with two copper pans, of the same internal area, but very unequal thicknesses of bottom, (being in proportion as 1 to 12,) which were both filled with water, and dipped into a hot solution of muriate of lime. It was found that the water in the thick pan evaporated the quickest, which may be accounted for by its slightly increased external surface in contact with the heating solution; and this affords additional evidence that the limit of transmission does not lie within the metal, but rather between the metal surface and the liquid. That the absorption of the heat by the water is a slow process, may be inferred from the circumstance that water, although possessing a large capacity for heat, is a very bad conductor, and depends for its power to absorb heat on the slow circulation over the heating surface, caused by the inferior specific gravity of the heated particles of water. A strong artificial current along the heating surfaces greatly accelerates the process.

The Surface Condenser, above described, was arranged in accordance with these observations.

It contains:—Heat-absorbing surfaces, (by the water,) 18 sq. feet per horse-power; condensing surfaces, 9 sq. feet per horse-power; computed mean thickness of metal through which the heat is transmitted, 1¼ inch; weight of copper, 60 lbs. per horse-power; space occupied by plates, 0.4 cubic feet per horse-power; about one tenth part of the space occupied by the tubes in the Tubular Condenser.

The essential features of this Condenser are, its comparative cheapness of construction, and the easy access which it affords to the water channels between the plates.

It also requires less condensing water than previous Surface Condensers, in consequence of the repeated and close contact in which each particle is brought with the heating surfaces, before it can reach the upper reservoir, or hot-well. The author considers that the Surface Condenser just described may be

advantageously applied to marine Engines, and being not subject to a patent, he hopes it will receive a sufficient trial.

Being required to save the waste steam of a low-pressure Engine, in the form of slightly-heated water, by Mr. John Graham, of Manchester, the author, in the spring of 1847, conceived the idea of a Regenerative Condenser. Figs. 4 and 5, Plate 40, show his first arrangement, which may be termed a Regenerative Surface Condenser. It consists of a revolving valve, B, which admits the waste steam of the Engine first to the atmosphere, at C, and, successively, into the separate compartments, D, E, F, G, where it is condensed at various densities. The cold water enters at H, and first passes between the plates within the last compartment, and by degrees through those within the first compartment, where the steam is of nearly atmospheric pressure, and consequently heats the water to nearly 212° Fah., when it passes out at I.

The next step was an Injection Condenser, on the same principle as represented by Fig. 6.

The revolving valve, B, admits the waste steam of the Engine, first to the atmosphere, at C, and then successively into the separate compartments, D, E, F, G, where it is condensed at various densities. The cold water is injected at H, and is passed down through the steam in each compartment in succession, by means of the displacing pistons, K K, which work all on the same piston rod through each of the divisions between the compartments; and the heated water passes out at the bottom, at I.

L L are overflowing distributing trays, for the purpose of bringing the water more rapidly and completely in contact with the steam. M is a small pump to extract the air that is mixed with the steam and water.

The Regenerative Condenser, in its present form, partakes of the nature of both the Surface and Injection Condensers.

Attempts have been made, from time to time, to condense the steam of a high-pressure Engine, without the aid of an air-pump, by blowing the steam into a small Injection Condenser, which is provided with a large exhaust valve.

It is clear that the steam of high pressure will, at first, par-

tially blow through the Condenser, and rid it of its air and condensing water, and that, by degrees, the jet of cold water will overpower the influx of steam, and consequently produce a vacuum. An arrangement of this description, although simple, is at least very imperfect, because it is a matter of considerable difficulty so to proportion the injection of cold water, that the first rush of steam is not forthwith condensed, but may exert its expansive force in a cold vessel, and yet, an instant afterwards, effect a complete condensation of the remaining steam.

If too much water be used, the air and water will not be expelled, and consequently no vacuum be formed; if too little, no final condensation will take place.

The quantity of injection water must be very large, because the whole of the steam has to be condensed; and having to complete the condensation in the same vessel, it must leave it at a low temperature.

The principle of the Regenerative Condenser has been carried still further in the Regenerative Engine, which has been executed on a large scale by Messrs. Fox, Henderson, and Co., under the superintendence of the author. In it, the steam, after it has served to propel the working piston to the end of its stroke, is received into a series of consecutive chambers, from which it returns to the working cylinder an indefinite number of times.

On a future occasion, the author will be glad to bring the particulars of this Engine before the Institution.

Table of the Pressure of the Vapour of Water, from the Freezing to the Boiling point.

TEMPERATURE. Fahr.	PRESSURE. Ins. Mercury.	TEMPERATURE. Fahr.	PRESSURE. Ins. Mercury.
32	0·20	130	4·34
40	0·26	140	5·74
50	0·37	150	7·42
60	0·52	160	9·46
70	0·72	170	12·13
80	1·00	180	15·15
90	1·36	190	19·00
100	1·86	200	23·64
110	2·53	210	28·34
120	3·33	212	30·00

Mr. SLATE inquired, what difference had been found in the consumption of fuel, in the engine at the Saltley Works, when the condenser was at work and when it was not at work?

Mr. SIEMENS replied, that the experiment had been tried with one week's working with the condenser, and then one week without it; and the saving of fuel with the condenser was at the rate of 18 per cent. The apparatus with which the condenser worked was, however, too light, and had not been made for the purpose; also, that condenser was the first that had been made, and the proportions had been improved in the subsequent ones.

Mr. WRIGHT confirmed Mr. Siemens' statement of the saving in fuel, and said there was a difference of about 8 cwt. in 1¼ days. There had been irregularities in the working of the engine, and several stoppages had occurred from defects of the apparatus, which was too light.

Mr. SIEMENS said, there was a deficiency in the supply of condensing water, which sometimes interfered with the regular working of the condenser, as well as the defects arising from the gearing being too light for working it, and these had caused irregularities in the working of the engine; there was also a difficulty in regulating the engine with the present governor, as a condensing engine. The steam pressure was 30 lbs. per inch; but a smaller supply of condensing water would be sufficient, if a higher pressure of steam were employed.

The CHAIRMAN thought that, in a locomotive engine, the extraordinary rapidity with which the jets of steam were discharged, constituted a great impediment to the application of the condenser.

Mr. SIEMENS replied, that it would only be necessary for the condenser to work quick enough to condense one cylinder-full of steam before the next cylinder-full was discharged, and this he thought would easily be effected by widening the plates of the condenser to a proportionate size, and shortening the stroke of the condenser piston, so as to reduce its velocity as far as might

be required. It would then return to the tender in pipes, between which air was caused to circulate by means of the rapid motion of the engine.

The CHAIRMAN observed, that there would be difficulty in keeping the water of the tender cool enough for condensing, when there was very little left in the tender; and the water remaining at the end of the journey, would be very hot and nearly boiling.

Mr. SIEMENS replied, that he expected the condensing water would be cooled down to about 100°, before it was returned to the tender, by the process of passing through the pipes of the refrigerator, from the rapid motion of the engine through the air; and the water was not required to be so cold as in the ordinary condenser, as only the last portion of the steam was condensed by injection.

Mr. COWPER observed, that only a small portion of the steam reached the injection water, the greatest portion being condensed previously, by the metallic plates, or discharged into the atmosphere; therefore the injection water might be about the same temperature as it usually came from the ordinary condenser. Also, the tender would not get empty so soon as usual, because a portion of the steam was condensed and returned back into the tender, instead of the whole being blown up the chimney: this gain might amount to one third of the water employed.

Mr. SIEMENS showed, by a comparative indicator diagram, that with the application of the condenser to a locomotive engine, the steam might be cut off at about one third of the stroke, instead of at two thirds as usual, and thereby a saving of one half the steam would be effected, with the same power.

The CHAIRMAN said, the subject of the application to locomotive engines was one of great importance, and he hoped it would be brought before the Institution in another paper. He proposed a vote of thanks to Mr. Siemens, for his paper, which was passed.

The following paper, by Mr. Archibald Slate, of Dudley, was then read:—

ON A NEW BLOWING ENGINE, WORKING AT HIGH VELOCITIES.

At a former meeting, the writer laid before the Institution the opinions which he entertained on the subject of Blowing Cylinders, proposed to be driven at high velocities, concluding that there would result thereby a large economy in the manufacture of iron throughout the entire plant and appliances of this indispensable machine. (See Report of Proceedings, July, 1850.)

It was observed in the former paper that, since the application of the double-acting movement, introduced some fifteen years ago, the Blowing Cylinder has remained, up to the present time, without a single other essential improvement. As left at that period, it continues a large and cumbrous machine, with complicated and slow motion; insomuch that the light and elastic body of the atmosphere is driven through at no higher velocity than the more ponderous body, water, can be passed through an ordinary pump. While the motive power was derived, in most instances, from a waterfall, there might indeed be alleged some semblance of a reason for the slow motion that has been spoken of; although, even in such circumstances, it is but little conceivable how the intervention of machinery, to quicken the passage of the lighter and elastic medium, should so long have remained a desideratum. But the question becomes infinitely more inexplicable, since the motive power employed has in almost every instance been steam, itself a medium in the highest degree light and elastic; capable, at the same time, of being worked under a pressure, and at a velocity, far beyond anything required at present, or that probably ever will be required of the air from a Blowing Cylinder.

Such being the facts, and contemplating the power and speed attained on the Railway by Locomotive Engines, the writer was led to reflect that a similar power was at least capable of being applied to the Blowing Cylinder; and, while impressed with this train of thought, he had occasion, in the latter part of the year 1848, to make use of some small 9-inch cylinders, driven by air from a larger Blowing Engine. It was then remarked that

these small Engines, when driving shafts only, sometimes attained a velocity of 200 revolutions per minute, under the ordinary blast pressure; when the idea suggested itself, that it might be possible to reverse their motions, making them Blowing Cylinders in place of Air Engines; and this idea, on being tested, turned out to be correct.

The cylinder experimented on was of 9 inches diameter, and one foot stroke, and being driven at the rate of 320 revolutions per minute, discharged the air at $3\frac{1}{2}$ lbs. per square inch, through a tuyere of $1\frac{1}{8}$th inch, being exactly $\frac{1}{64}$th part of the area of the blowing piston. This performance exceeds, as is well known, by double its amount, that of any ordinary Engine; the total area of the tuyeres, with a 90-inch Blowing Cylinder, at a pressure of $3\frac{1}{2}$ lbs., being about 50 circular inches, which is only $\frac{1}{144}$th part of the area of the Blowing Cylinder.

Assured by the complete success of this experiment, the writer proposed to construct a Steam and a Blowing Cylinder of two-feet stroke; the cylinder for steam to be of 10 inches diameter, and that for blast of 30 inches; and to couple them, if necessary, with a second and similar set, acting at right angles upon a common axle; and he is still of opinion that such would probably prove the best arrangement, as well as the best proportions to observe in construction. (See Plate 11, in Proceedings, July, 1850.)

But in the actual experiment, the cylinders proposed to be placed at right angles have not yet been constructed. The size of that used, owing to peculiar circumstances, has been considerably enlarged. In 1850, finding that more air was required for the manufacturing purposes to which it was applied, the writer and Mr. Cochrane (his partner) resolved to make a Blowing Cylinder of such a size as would practically test the question of high velocities; and a Steam Engine, having a Cylinder of 14 inches diameter, being ready at hand, was fitted with a 40-inch Blowing Cylinder, and to this Engine the further remarks have reference. The stroke is 2 feet; the total weight of the Engine about 6 tons; the boiler made use of weighed 3 tons, 13 cwt.; its length over all is 27 feet, having egg ends; its diameter 4 feet.

The first set of experiments were made in presence of Mr. Beyer, Mr. McConnell, Mr. Daniel Gooch, Mr. Geach, Mr. Evers, Mr. Cochrane, and several other gentlemen who took an interest in the proceedings, which were of the following nature.

On the outlet pipe were placed four tuyeres: two of them 2¼ inches diameter, and the remaining two 2 inches diameter, all blowing into the open air. The Engine being run up to its full velocity, reached 145 strokes per minute. At this rate, the density of the air issuing from the four tuyeres approached nearly to 5 lbs. per inch, the Engine remaining perfectly noiseless and steady, and the blast being so continuous and regular, that the mercury in the barometer did not vary more than ⅛th of an inch—in fact, continued barely living in the tube.

A variety of minor experiments followed, not necessary to be dwelt upon at present; but it is believed perfectly warrantable to state, as the result, that each person present felt convinced that he had seen exhibited a Blowing Machine of at once a powerful, cheap, and efficacious character.

Although the experiments thus detailed were of the most satisfactory description, and indeed had exceeded every expectation of a first performance, the writer nevertheless felt convinced, from observation of the working, that the steam might be considerably economised; and before proceeding to apply it to actual use, resolved to fit the engine with an adjusting expansive valve, by which such economy might be realised. When this had been fitted, and the requisite attachments made, its full complement of blast was thrown into one furnace, viz.: 3500 cubic feet of air per minute; the pressure of the air in the main, close upon the engine, was a little in excess of 3 lbs. to the inch; at the tuyeres on the furnace, it was, if anything, rather under 3 lbs.: but this slight discrepancy probably took its origin from the tortuous character and length of the main, which exceeded 300 feet; a circumstance which it was found impossible to avoid, without leaving out of consideration the objects to which the new blowing power is ultimately to be applied.

The Engine, during the trial, varied from 96 to 100 strokes per minute. The steam from the one small boiler, 27 feet by 4,

remained full and sufficient for this work, after the Engine had worked every day for nearly a month, and had been seen by Mr. Benj. Gibbons, and several other persons connected with the iron trade. An opportunity again occurred of trying it upon one furnace, with the same result as above; this last experiment was made in the presence of Mr. Samuel Blackwell. With regard to fuel, on a subsequent trial, while working in connection with a larger Blowing Engine of the ordinary sort, delivering into the mains 3000 cubic feet of air, at a density of 3¼ lbs. to the inch, it was found to amount, by measurement, to 2 tons 5 cwt. of small refuse coal, or slack, in twelve hours.

Although the writer does not present the arrangement of the Engine, here given, as a perfect machine, he can entertain no doubt that the development of the principle must greatly stimulate the production of iron. It will be perceived how, by the use of Blowing Machines, working at high velocities, the expense of plant and machinery for blowing a furnace may be reduced, at the rate of 65 per cent., from what it stands at present; or, to one third of the present amount. The above-mentioned experiments at Woodside have proved such Engines to be adequate to as large a class of works as exist in Staffordshire. Their simplicity and portable character make them equally available at the smallest charcoal furnaces, in however remote a quarter there might be occasion for their use.

Mr. MIDDLETON inquired, whether the blast from the small engine went direct to the furnace, or through a reservoir?

Mr. SLATE said, they had a receiver, 12 by 4 feet; but in the experiment with one furnace, when the other was in repair, they let it blow through the whole of the large air main.

Mr. MIDDLETON said, that he remembered the late Mr. Murdock worked a similar blowing engine at Soho, twenty-five years ago; it was direct-acting, and the only difference was that it had a D valve, and worked at a slower velocity than Mr. Slate's engine.

The CHAIRMAN said, he had a similar blowing engine in

regular work at Wolverton, only working vertically instead of horizontally; but his engine only made from fifty to sixty strokes per minute, while that now under description performed one hundred and thirty in the same time. This gave the blowing engine of Mr. Slate a great advantage, and was its distinctive feature; the great gain was in the high speed employed.

Mr. DAVIES observed, that Mr. Slate's engine could give a steady blast for a furnace, with full pressure, which Mr. Murdock's engine could not do.

Mr. SLATE remarked, that, though Mr. Murdock's engine had been at work at Soho for the period stated, no further progress had been made in the construction of the blast engine; for at Soho they still continued to make only the old ponderous engines.

Mr. MIDDLETON said, it had been applied at the smithy at Woolwich, and had been at work there for many years. He thought, though Mr. Slate's engine was different in some respects, it was similar in principle to Mr. Murdock's.

Mr. W. SMITH was quite satisfied that Mr. Slate's engine would maintain a constant blast for a furnace. He had seen Mr. Murdock's engine at work; it was an open-top cylinder, and was quite another kind of engine. He thought that Mr. Slate's plan of blowing engines was an important advantage in the saving of expense in the erection of iron works, and he believed that a blowing engine could now be erected for £500 on that plan, as well as one on the old plan for £1500, to do the same work.

The CHAIRMAN thought that Mr. Slate's engine was certainly deserving of approbation, and he hoped that he would continue his investigation of the subject, as any improvement or economy in the manufacture of iron was of great importance.

A vote of thanks was passed to Mr. Slate for his communication.

The following paper, by Mr. E. A. Cowper, of Birmingham, was then read :—

ON AN IMPROVED MODE OF MOULDING RAILWAY CHAIRS.

In laying before the Institution a short account of a new mode of casting Railway Chairs, it is thought that no apology is necessary for the introduction of such an apparently dry matter of detail, as it has ever been the great aim and object of this Institution to thoroughly discuss, and, as far as possible, pass a sound practical judgment on, mechanical inventions affecting the interests of the public generally.

The improved mode of casting Railway Chairs is confidently submitted to the judgment of the members; and as the invention is simply a *cheaper mode* of producing *better castings*, it may be described in a very few words.

The importance of a Railway Chair being a strong, *accurate*, and *sound* casting, must at once be apparent to every mechanical man; and, indeed, it is probable that the majority of the members present have travelled over many hundred thousand chairs during the past week, the failure of any one of which might have been attended with most serious consequences.

Now, if it can be shown that, in addition to producing a more *perfect casting*, it can be done at a *cheaper rate* than usual, it is presumed that the new mode may be considered an *improved* method of casting Railway Chairs.

On referring to the engraving, (Plate 40,) it will be seen that A A, in Fig. 1, is the iron *pattern;* and it is necessary here to observe, that the inside of the *pattern* is *not* the shape of the intended Chair, but the edges of the jaws are provided to receive cast-iron *chill-plates*, B and C, which are made so as to give the required form to the inside of the casting. These *chill-plates* are dotted in Fig. 1, and they are shown separately in Figs. 2 and 3, and in section, in Fig. 4.

The *pattern* being placed in the moulding box, as shown in Fig. 1, the chill-plates are placed therein, one in contact with each jaw of the pattern. The sand is now thrown into the box, and some of it is rammed between the chill-plates, thus effectually securing their close contact with the pattern; the

remainder of the sand is then rammed in, until the box is full. The box and its contents are then turned upside down. in the usual way; the pattern is slightly rapped, and then withdrawn, by means of a screwed lifting-pin; the chill-plates being left in the sand, forming a good guide to the pattern as it is withdrawn. The top box is then put on, having previously been rammed up on another board, technically called an "odd-side board;" the melted metal is then poured in, and the casting is complete. As soon as the metal has thoroughly set, the casting may be turned out, and the *chill-plates* will *drop out of themselves.* The finished chair is shown in Fig. 5, and D D are the two portions that are cast in the chills, B and C.

The box exhibited to the meeting has been rammed up in the manner described—the chill-plates may be clearly seen, firmly imbedded in the sand; and it is remarkable what great force is necessary to displace them.

The chill-plates are simply good castings, made from an iron pattern, and are not filed up, or fitted in any way, as the iron pattern of the Chair is fitted to them, and the metal-chills being closely pressed by the sand against the metal pattern, great accuracy is obtained in the position of the chills; indeed, it is a very rare thing for the shape or inclination of the jaws of the Chair to vary anything like $\frac{1}{32}$nd of an inch; therefore, when the wrought-iron rail is placed within the Chair, the correct inclination is accurately given to it; and if the rail be true, the Chairs cannot be *winding*, or out of parallel with each other.

It is found that the chill-plates stand exceedingly well, and in fact many hundred tons may be cast off one set of them; this is partly owing to their not being very thick, so that they soon get hot through, and do not strain or warp at all; the Chairs are chilled just sufficiently to give a good, true face, but are not chilled-in very deep, in consequence of the chill-plates not being very thick, and the Chairs themselves containing a large quantity of metal.

On this plan of casting Chairs, boys only are employed for moulding, as the great ease and safety with which the pattern is withdrawn entirely does away with the necessity of regular

moulders being employed; thus the cost of manufacturing Railway Chairs is brought to a minimum.

In conclusion, it may be stated that many thousand tons have already been cast on this plan, and that it bids fair to be universally adopted.

Mr. COWPER exhibited specimens of the chairs and the patterns, and the process of moulding. He said that, by that process of casting, there were scarcely any wasters made, not more than one in five hundred, which effected a great saving in the expense.

Mr. SLATE said, the plan proposed was unquestionably very simple and ingenious, and one which any boy might easily be taught to understand. He wished to ask Mr. Cowper what he considered the saving in expense would be, by his plan?

Mr. COWPER observed, that none but boys were employed in the moulding of the chairs. The saving, he considered, in an ordinary way, would be about four shillings per ton.

Mr. MIDDLETON enquired, what was the difference in the plan of casting chairs from that of Messrs. Ransome and May?

Mr. COWPER explained, that their plan was to have an iron plate or chill fitting the side of the box, and the chill-block fixed into that by a small dovetail. This block had to be driven out before the chair cooled, and the chairs sometimes were strained by the contraction before the block could be got out, and were broken or injured; but in his plan there was no strain in cooling. Also, his plan ensured the inclination of every chair being quite correct, because the chill-plates were held so firmly; but in that of Messrs. Ransome and May, there was a degree of uncertainty in the inclination, from the block being held only at the side. He might mention, that they had so far approved of his plan as to arrange for adopting it in their manufacture. His chair could be made perfectly parallel

inside, but in their chair there was obliged to be a little taper inside, to allow of driving out the block after it was cast.

In the old chairs they were compelled to use taper keys, which frequently got loose, but with this chair the keys could be used quite parallel, and when they became swollen by the moisture, formed a head at each end, which prevented the keys from ever getting loose.

The CHAIRMAN observed, that Mr. Cowper's plan appeared to be a decided improvement, both in the accuracy of casting the chairs, and in economy of manufacture; and he proposed a vote of thanks to him for his paper, which was passed.

The CHAIRMAN announced that the ballot lists had been opened, and the following new members, &c., were duly elected :—

MEMBERS :

JOHN ADDISON, London.
WILLIAM BATLEY, London.
CHARLES NIXON, Cork.
EBENEZER ROGERS, Abercarne.
CHARLES W. SIEMENS, Birmingham.
JAMES THOMPSON, Manchester.

GRADUATE :

J. THORPE POTTS, Birmingham.

HONORARY MEMBERS :

THOMAS D. CLARE, Birmingham.
WILLIAM D. STARLING, London.

The meeting then terminated.

Printed at M. BILLING'S Steam-Press, Newhall Street, Birmingham.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 22ND OCTOBER, 1851.

ARCHIBALD SLATE, ESQ.,

IN THE CHAIR.

BIRMINGHAM:

PRINTED AT M. BILLING'S STEAM PRESS OFFICES,

74, 75, & 76, NEWHALL STREET.

1851.

PROCEEDINGS.

THE GENERAL MEETING of the Members was held at the House of the Institution, Newhall Street, Birmingham, on Wednesday, 22nd October, 1851, ARCHIBALD SLATE, Esq., in the Chair.

The Secretary read the Minutes of the last General Meeting, which were confirmed.

The CHAIRMAN announced that, according to the Rules of the Institution, the President, Vice-Presidents, and five of the Council, in rotation, would go out of office next year; and that. at the present Meeting, the Council and Officers for the next year were to be nominated for the election at the next Annual Meeting. He then read the following list of Members, proposed by the Council for nomination, with the addition of any other members who might be proposed by the Meeting.

PRESIDENT:

* ROBERT STEPHENSON, M.P.

VICE-PRESIDENTS:

(*Three of the number to be elected.*)

* CHARLES BEYER, Manchester.
EDWARD HUMPHRYS, Woolwich.
EDWARD JONES, Bridgewater.
* J. E. McCONNELL, Wolverton.
* JOHN PENN, London.
R. B. PRESTON, Liverpool.
ARCHIBALD SLATE, Dudley.

COUNCIL:

(Five of the number to be elected.)

JAMES BROWN, Birmingham.

P. R. JACKSON, Manchester.

* MATTHEW KIRTLEY, Derby.

* JAMES KITSON, Leeds.

JOHN R. McCLEAN, London.

* RICHARD PEACOCK, Manchester.

* R. B. PRESTON, Liverpool.

* JOHN RAMSBOTTOM, Manchester.

THOMAS RICHARDS, Worcester.

THOMAS WALKER, Wednesbury.

TREASURER:

* CHARLES GEACH, M.P., Birmingham.

SECRETARY:

* WILLIAM P. MARSHALL, Birmingham.

(The Officers for the present year are marked thus *.)

No other names having been added by the Meeting, the above list was adopted.

The following paper, by Mr. JAMES A. SHIPTON, of Manchester, was then read:—

ON THE DIRECT CONVERSION OF RECTILINEAR INTO CIRCULAR MOTION IN THE STEAM ENGINE.

The years that have elapsed since the Steam Engine was first generally introduced as a prime mover, and the few alterations that have taken place, notwithstanding the many threatened invasions of

a variety of ingenious inventions, must lead to the reflection that only a master mind could have combated with the difficulties that beset such an undertaking, and have sent it forth to the world in so perfect a form; the unskilled hand of the workman being the only drawback from its being then what it is now.

The costly work of the various parts subjected to immense strain, and also to the searching and penetrating action of steam, depended then entirely upon the manual dexterity employed, and therefore the machinery of the Steam Engine was required to be of the most simple form to place it within the reach of even the most opulent; but as its use and value presented itself to the country at large, so the development of machinery took place to meet the demands of its manufacture; and, though it must be acknowledged that the same mind that brought the Steam Engine into commercial operation, contemplated also the reduction of its cost, by the use of self-acting machinery in the production of its parts, yet the task of bringing such into operation has been nearly as arduous as the former one. What the mechanic would then have looked upon as an impossibility, is now perfectly simple, and the cost in comparison trivial.

That the principle of the ordinary Steam Engine as regards the reciprocating action of the steam cannot be improved, is the author's opinion; but also that its mechanical construction may be materially altered, and improvements effected in this respect, owing to the many advantages possessed at the present time of having tools to meet every requirement; the rapid progress made in this branch of mechanical science having placed the Steam Engine in its present commercial position.

The subject of the present paper is the "Direct Conversion of Rectilinear into Circular Motion," and also brings under notice a Steam Engine, not deviating in principle from the ordinary reciprocating engine. but simply in its construction; as the inventors feel convinced the nearer they approximate to the original the less liable they will be to err. The diagram, Figure 1, Plate 42, represents a piston and crank engine of ordinary construction, and although the whole area of the piston be exposed to the pressure of the steam throughout the stroke, (supposing the valve be kept open,) there are certain points when this pressure is useless, namely, when the

crank is on the centre; thus, the circular motion of the crank restricts the piston from exerting its full force with regard to that circular motion, and thereby the velocity of the piston is constantly varying throughout the stroke, as also the power exerted and the steam consumed in like proportion. Thus the actual power exerted is the average velocity of the piston multiplied by the pressure.

Now, an eccentric being a mechanical equivalent for a crank, if the area of the piston of Fig. 2 be equal to the area of the piston of Fig. 1, and the throw of the eccentric, B, equal to the stroke of the crank, A, they are of like power. Then, by altering the mechanical arrangement, as in Fig. 3, and placing a piston at top and bottom of the eccentric, or, in other words, placing the eccentric in a large piston, the area of piston and throw of eccentric being equal to B, an engine of like power is obtained. Therefore, A, B, and C, are equivalents of each other, differing only in mechanical construction; and the power obtained from each would be the same, not taking friction into consideration.

Dispense with these pistons, and admit steam alternately, top and bottom of the circle, D, in Fig. 4, and this eccentric piston would be propelled, up and down, in a rectilinear direction, and this motion would be converted into a circular motion, during the propulsion of the piston. Here is obtained the amalgamation of the two motions of the ordinary engine in one body; the same body containing the properties of the reciprocating piston, and also of the crank.

The practical application of this principle is effected in the Pendulous Engine, shown in Figures 5, 6, 7, Plates 42 and 43; these represent a 20 horse-power steam engine, which is a modification of an engine that was submitted by the author to a former meeting of the Institution.

A is the base-plate, that carries the entire engine. The side framing, B B, is fitted to it, and bolted firmly down, and upon this the cylinder, C, is suspended, and swings with a pendulous action. The piston, D, is turned perfectly true, having the shaft, E, keyed eccentric in it. This shaft works in pedestals, P P, which are fixed on the bed-plate. The piston works between two parallel

surfaces, F and G, the surface at F being a plate, dove-tailed into the cylinder, and the plate G is fitted into the recess prepared for it, and so arranged that, by means of adjusting screws, it follows up any wear that may take place on the periphery of the piston, and maintains a steam-tight joint. The piston is packed at the ends with the rings, H H, these being fitted into a conical seating, and as the wear takes place, they are sprung open by means of a small wedge and bolt inserted where the ring is cut open, to allow it to expand. These rings work against the side plates, I I, which are bolted to the cylinder, and have metallic joints. The peculiar motion of the ends of the piston against these surfaces causes a most beautiful wear, as the rings keep receding in their seatings, and never come over the same parts twice together.

Steam is admitted precisely the same way as in an ordinary engine, at top and bottom of the piston, but the valve, N, is on the equilibrium principle, and exhausts through the back, being packed by a conical ring, in a similar manner to the ends of the piston; the valve is worked by the eccentric, J, by means of levers and weigh shaft. The steam and exhaust pipes are shown at K and L, and are packed with the glands, M M, to admit of the pendulous motion of the cylinder. The distances between the centres are calculated so as to allow the pendulous motion of the cylinder to coincide with the rate of revolution of the engine, and consequently, only a small portion of the weight of the moving body has to be overcome, with respect to the vibration.

The advantages of this Engine are,—economy in first cost,—economy in space,—economy in foundations, being self-contained,—simplicity and economy in repairs, as the wearing parts are insertions, and may be renewed at a short notice,—direct application of the steam to produce the rotary motion of the shaft, without the intervention of joints or connecting rods,—and not being liable to derangement, as the moving parts are so few in number. As it contains less frictional surface than the ordinary engine, economy in consumption of fuel may be expected. High speed may be obtained, and thus gearing, wheel-work, &c., may be dispensed with; and from its compactness, this engine is most suitable for working the heavy class of machinery, such as rolling-

mills, &c., or screw-propellers in steamboats. A twenty-horse engine is being constructed on this plan, and will be at work in a few days, and the author will be ready, at a future period, to lay before the Institution its performances, tested by a dynamometer.

Mr. SHIPTON exhibited a working model of the Pendulous Engine, and illustrated its action by sectional models.

Mr. ELWELL enquired whether a similar Engine had not been at work for a considerable time at Wolverhampton? and what was the probable cost of such engines?

Mr. SHIPTON replied, that the engine at Wolverhampton was constructed on the former modification of the plan, in which the piston oscillated instead of the cylinder. The cost would be £9 per horse-power, exclusive of the boilers. The only comparative trial that had yet been made as to the consumption of fuel, was with an engine at Manchester, which showed a saving of 10½ per cent., as compared with another direct-acting engine which worked from the same boiler.

Mr. SIEMENS enquired how the packing was made steam-tight? And Mr. SHIPTON explained that it was by an expanding ring of triangular section, giving an equal pressure on both surfaces: the same plan was adopted for packing both the piston and the valve. He exhibited one of the packing rings.

Mr. CLIFT observed, that Mr. Shipton had argued that a considerable saving would be effected by avoiding the crank motion and the reciprocation of the piston; but he had against that the whole weight of the cylinder in motion, which was a large weight to be stopped and reversed at every revolution; and therefore he could not see what advantage the invention possessed over the ordinary engines.

Mr. SHIPTON replied, that the pendulous motion of the cylinder prevented the loss of power in reciprocation; the cylinder

vibrated as a pendulum; and they found that one man could work the cylinder of a 20-horse engine in vibration, at full speed.

Mr. CLIFT enquired whether the cylinder was made of correct length to vibrate, according to the law of a pendulum, at the actual working speed of the engine? as, if not correctly adjusted, it might require a large amount of power to force it into the required rate of vibration.

Mr. SHIPTON said, the remark would apply to all oscillating engines, but in this engine they had calculated the length of the centres of oscillation, so as to agree with the intended rate of working of the engine.

Mr. SIEMENS observed, that weight was certainly of secondary consideration, if the centre of oscillation could be made to agree with the corresponding length of pendulum; and such an arrangement would make the power more uniform throughout the stroke. But it would not be correct to consider the weight of the piston as a loss, in a reciprocating engine, as the momentum was gradually absorbed by means of the crank, and given out again in starting the return stroke. In some cases a heavy weight of piston and connecting rod was actually an advantage; an expansive engine, cutting off at half stroke, worked more steadily with a heavy connecting rod than with a light one, as it absorbed surplus power at one part of the stroke, and gave it out again when the moving power was deficient, tending to equalize the power. With respect to Mr. Shipton's engine, he considered the question to be one of comparative friction, compactness, and simplicity.

The CHAIRMAN understood Mr. Shipton to bring forward his engine rather as one presenting advantageous points of construction, than as one which led to saving in fuel. He proposed a vote of thanks to Mr. Shipton for his communication, which was passed.

The following paper, by Mr. J. E. Clift, of Birmingham, was then read:—

ON THE PRESERVATION OF TIMBER BY CREOSOTE.

In the present day, when the requirements for timber, in the various mining, engineering, and other works, are so great, it becomes necessary to consider carefully the best means of rendering it as durable as possible, and that at the least expense; and the writer cannot think that sufficient attention has been paid to the subject by the parties most interested, from the fact that but few of the larger consumers of that article have adopted any plans for its preservation; and this fact must be the apology for bringing before the Institution a paper upon a process which has been partially in use for several years.

In looking through the colliery districts, it is found that thousands of loads of timber are taken green from the forests and used every year; and the greater portion is used in the pits, where, owing to damp atmosphere and increased temperature, it is rotted in a few months; whereas, with a small expense, it might be made to last for years.

It may be observed, also, that the Railway engineers are seeking for a more durable bearing for the rails in iron sleepers, and overlooking the means of making wood, which is allowed to be the most agreeable for travelling upon, the most durable as well as the most economical material for the permanent way.

Wood may be briefly stated to be composed of a fibrous tissue, which upon examination with the microscope is found to consist of longitudinal tubes, arranged in concentric rings around the centre pith; these tubes varying in diameter from $\frac{1}{2000}$th to $\frac{1}{200}$th part of an inch. The use of these tubes in a growing tree is to convey the sap from the root to the branches; and after the tree is cut up for use, they contain the chief constituent of the sap, vegetable albumen —a substance very much resembling in its composition animal albumen, or the white of an egg. Different woods vary in the proportion which they contain of this substance, but in the softer woods it averages one per cent.

The dry rot in timber is caused by the putrefaction of the vegetable albumen, to which change there is a great tendency; and

when once this has taken place, it soon infects the woody fibre, inducing decomposition, and causing its entire destruction.

Many plans have been proposed to arrest this evil, each with more or less success; the chief aim of the authors being to coagulate the albumen by means of metallic salts, and so prevent putrefaction. Among others may be mentioned the following, as being the most successful:—Kyan's process, by the use of chloride of mercury; Burnett's, by chloride of zinc; and Payne's, by sulphate of iron and muriate of lime, forming an insoluble precipitate in the pores of the wood. To each of these plans there are serious objections in practice. In the first place, when metallic salts are injected into timber in sufficient quantities to crystallize, the crystals force open the pores, causing a disruption of the fibre, and when the timber afterwards becomes wet they dissolve, leaving large spaces for the lodgment of water, and rendering the timber much weaker. Secondly, the metallic salts being incapable of sealing the pores of the wood, the fibre is still exposed to the action called eremacausis, a process of oxidation, after the albumen has been precipitated. These processes are also objectionable for wood that requires iron inserted in or attached to it, as the acids act upon the iron in a manner well known, and ultimately destroy it.

The plan that is the subject of the present paper is the one invented by Mr. Bethell, for the use of a material obtained by the distillation of coal tar. This material consists of a series of bituminous oils, combined with a portion of Creosote; this latter substance being acknowledged to possess the most powerful antiseptic properties. The action of this material may be thus described:—When injected into a piece of wood, the Creosote coagulates the albumen, thus preventing the putrefactive decomposition, and the bituminous oils enter the whole of the capillary tubes, encasing the woody fibre as with a shield, and closing up the whole of the pores, so as entirely to exclude both water and air; and these bituminous oils being insoluble in water, and unaffected by air, renders the process applicable to any situation. So little is this oil affected by atmospheric change, that the writer has seen wrought-iron pipes that had merely been painted over with it, and laid in a light ground

cylinder, and exhausting the air from it by an air-pump, until a vacuum is created, equal to about twelve pounds on the square inch; the creosote is then allowed to flow into the cylinder, and afterwards a pressure is put upon the creosote, by a force-pump, equal to about 150 pounds on the square inch; the timber then taken out is fit for use. This apparatus is shown in Plate 44.

A The wrought-iron pressure tank.
B Cast-iron cover, fixed by strong clamps and screws.
C Small crane, for removing the cover.
D Carriages for holding the timber, E, that is to be creosoted. These carriages run on a railway in the tank, for facilitating the charging and discharging of the tank.
F Iron cramps, fixed to the carriages, for confining the timber to the proper space for entering the cylinder. Small blocks of wood are used to keep each piece of timber a certain space from any of the others.
G Reservoir for the creosote.
H Steam-pipe, for warming the creosote.
I Steam-engine.
K Air-pump, for exhausting the pressure tank.
L Force-pump, for injecting the creosote.
M Discharge pipe, for emptying the tank, with safety valve, for letting off the superfluous creosote, when the required pressure has been attained.

The second process is by placing the timber in a drying-house, as shown in Plate 45, and passing the products of combustion through it; thereby not only drying the timber rapidly, but impregnating it, to a certain extent, with the volatile oily matter and creosote contained in the products given off from the fuel used to heat the house. When the timber is taken out of this house, it is at once immersed in hot creosote in an open tank, thus avoiding the use of a steam-engine, or pumps.

AA Drying-house, built with hollow walls, filled in with ashes.
B Fireplace.
CC Flue, running the whole length of the building, covered with iron plates, perforated for half the length farthest

from the fire, to allow the products of combustion to pass through the timber on the way to the chimney.

D Carriages, for holding the timber, E, that is to be creosoted, running on a railway for facilitating the charging and discharging of the drying-house.

F Iron doors, closing the end of the drying-house.

Mr. Clift exhibited specimens of Creosoted Sleepers, which had been in use for ten years on the London and North Western Railway, near Manchester, and were still perfectly sound and unchanged; also specimens of Creosoted Piles from Lowestoft Harbour, which had been in the sea for four years, and continued quite fresh and sound, and without being touched by the worm; with specimens of similar piles uncreosoted, from the same situation, which were completely eaten away and honeycombed by the worm in the same period.

Mr. Bethell observed, that when he first commenced to preserve timber, he found that no pressure would get the creosote into the timber from the presence of moisture in the pores, and it became necessary to adopt the system of drying the timber first; and after fourteen days he found that the wood lost 3 lbs. in weight in every cubic foot; this was by the old process of drying. He then introduced the present drying-house, and in twelve or fourteen hours they lost 8 lbs. per cubic foot, in Scotch sleepers, and these then absorbed an equal weight of creosote. An average of 11½ lbs. of creosote per cubic foot was now put into all the Memel timber at Leith harbour works; it was forced in with a pressure of 180 lbs. per inch. One piece of creosoted timber had been observed at Lowestoft, which had been half cut through for a mortice, but not filled up again, and a teredo had penetrated a little way into it at that part, and then attempted to turn to the right, and then to the left, and had ultimately quitted the timber with-

out proceeding any farther. Young wood was the most porous round the exterior, and consequently absorbed most creosote, which formed a shield to keep off the worm. The creosoted sleepers were better after eight or ten years than when new, because the creosote got consolidated in them and rendered them harder. He had taken the idea originally from the Egyptian mummy; it was exactly the same process; any animal put into a creosote tank assumed the appearance and became in like condition to a mummy. Timber creosoted was now chiefly used in railways, but he believed that if it was introduced into coal-pits it would be found that no timber so used in those places would rot.

The CHAIRMAN remarked that if the owners of pits found it so much to their advantage, he was sure the plan would come into use.

Mr. CLIFT said he had taken up the subject in the present paper with that view; his object was to draw attention to pit timber, and he was satisfied that if the timber used in coal-pits was creosoted, it might, when done with in one situation, be again taken out to use in another place; whereas now, because the dry rot seized the timber so quickly, it was left behind in the workings of the pits.

The CHAIRMAN enquired whether, in the process of creosoting, the quantity of sap extracted was calculated? and how the exact quantity of creosote that was put into the timber was ascertained?

Mr. BETHELL replied, that every piece of timber was weighed before it was put into the creosote tank, and again when taken out, and each piece was required to be increased in weight by the process 10 lbs. per cubic foot; the quantity of oil used always rather exceeded the weight gained in the timber, on account of the loss of weight from the moisture extracted by the exhaustion of the air-pump.

The CHAIRMAN enquired what difference was found in the quantity of creosote absorbed by the harder woods?

Mr. BETHELL replied, that oak only absorbed half as much

creosote as Memel timber. Common fir creosoted would last double the time of hard wood creosoted, because it took more creosote. Beech made the best wood, being full of very minute pores, and they could force a greater quantity of creosote into beech than into any other wood; consequently it took a more uniform colour throughout from the process.

Mr. SHIPTON enquired how the process was regulated to allow for the difference in size of timber?

Mr. BETHELL said that long pieces of timber were found to require more time to saturate them in proportion to their length, and the creosote appeared to enter at the two ends and be forced up through the whole length of the pores. The progress was known by the quantity of creosote forced into the tank after it was filled, according to number of cubic feet of timber contained in the tank.

A vote of thanks was passed to Mr. Clift for his communication; and the following paper, by Mr. Archibald Slate, of Dudley, was then read:—

NEW EQUILIBRIUM CANAL LIFT, FOR TRANSFERRING BOATS FROM ONE LEVEL TO ANOTHER, WITHOUT LOSS OF WATER OR OF POWER.

The scarcity of water in the inland navigation during the summer months, and the consequent inconvenience to the manufacturers who are dependent for an outlet on that mode of conveyance, having led the author of the present paper to the investigation of the various plans which had been proposed or tried, for transferring boats from one level to another without the loss of water which occurs in the use of locks—he found that there existed in these plans what appeared to him an insuperable objection—the necessity of water-tight gates or sluices, to be opened and shut in the passage of each

boat, and the least derangement of which might not only stop the traffic of the canal, but be productive of most serious consequences. There occurred in some plans the very serious evil of the boats being transferred from their proper water bearing to a dry or partially dry cradle, causing serious risk of injury to the boat, by the strains arising from the unequal bearing.

It appeared, then, that to the successful application of any lift or method of transferring boats, two points were essential: first, that the boats should float in water during transfer; and next, that there should be a total absence of gates or sluices in the main line of the canal.

To make the boats float into a caisson or tank, sunk in the water, disposed of both the above points at once; and the only thing then to be sought for was the proper mechanical arrangement by which the caisson, with the boat floating in it, might be lifted out of the water at the one level, and transferred to the other level, without the loss of water, or the use of more power than is necessary to overcome the friction of the machinery.

The method by which this is proposed to be accomplished is shown in Plates 46 and 47.

The upper level of the canal is divided into two branches or arms, U U, each of a sufficient width, and carried along each side of the lower level of the canal, V, to a sufficient length, to receive an ordinary canal boat. The sides of the canal forming the upper levels may be constructed of stone and brickwork, as in ordinary locks, or of iron carried upon timber framing. The depth of each branch of the canal is sufficient to permit a boat, W, with a full load, to float over the ends of a caisson or tank, D D, that is of sufficient size to contain water enough to float a loaded boat.

Over these branches of the canal is erected a timber or iron framework, upon the top of which, at points immediately over the upper and lower branches of the canal, are fixed rails, A A, and on these rails are placed carriages, B B, containing a series of wheels, over which run the chains, C C, for lifting the caissons.

At the bottom of one of the branches of the canal, on the upper level, and of one on the lower level, are placed the iron caissons or

tanks, D D, which are carried by straps, attached to cross bearers, E E, and suspended by the chains at points immediately under the framework.

At one side of the framework, in two vertical grooves, is suspended the large shaft, F F, carrying the four drums, G G, on which the suspending chains wind and unwind in the operation of raising and lowering the caissons; the two sets of chains being wound on the respective drums in opposite directions, so that when one caisson is raised, the other is at the same time lowered. On each end of this shaft, F, is a bearing or journal, which is grasped by an eye or strap, H H, in which it can revolve; to these straps is attached one end of the equilibrium connecting chains, I I, the other ends of which are fixed to the cams, J J. These cams are keyed fast on the shaft, K, and on the same shaft are also keyed two other cams, L L, to which is attached, by two chains, the balance weight, M. On the same shaft are keyed the large wheel, N, and two drums, O O, to which are attached, on opposite sides, the two water buckets, P P, for the purpose of aiding, if required, the manual power in working the lift.

The balance weight, M, is nearly equal to the weight of the caissons in the water, when working through the shortest leverage of the cams; the caissons being allowed a little weight in excess, in order that they may freely sink to the bottom of the water. The balance weight, when acting through the longest leverage, (as shown by the dotted lines,) is equal to balance the caissons when out of the water and full of water; this weight of the caissons being *the same under all circumstances*, on account of the relative displacement of water, whether they contain a loaded boat or an empty boat, or are merely filled with water, without any boat. The form of the cams between these two extreme points is regulated by the form and depth of the caissons.

The following is the action of the Equilibrium Lift:—Supposing two loaded boats approaching the lift, one on the upper and the other on the lower level of the canal; (but the same description applies to empty boats, or to a single boat,) each boat is floated into the arm of the canal, over the caisson lying at the bottom, in the

same way as into ordinary locks. The first operation of lifting, is to raise both caissons out of the water, with the boats floating in them: this is done by applying power to the series of wheels, Q, which turn the shaft, K; by which operation the chains, I I, are wound on the cams, causing the shaft, F, with the drums and suspending chains, to move down the vertical grooves in the framework to the position shown by the dotted lines at R, and thus raising the caissons and boats out of the water. This operation may be performed either by manual power or by means of the water buckets, P P, by turning on water from the upper level into the descending bucket, and letting out the water, by a self-acting valve, on the bucket reaching the bottom. The varying weight of the caissons, in progress of being raised from the bottom to the surface, until out of the water, is allowed for, so as to preserve the equilibrium throughout the operation, by the varying leverage of the balance weight acting upon and through the four cams; so that the power has little more than the friction of the machinery to overcome.

Having by this means lifted both caissons out of the water, that one which is required to descend to the lower level is moved across the bank of the canal, by means of the railway, A A, on the top of the framework, in a similar manner to an ordinary traversing crane, until it is suspended over the lower branch of the canal, ready to descend, as shown by the dotted lines at S. When in this position, the wheel, T, on the end of the shaft, F, is geared to the series of motion wheels, Q, by means of a shifting clutch, at X; the power is then applied, and the shaft caused to revolve, which by unwinding the chains attached to the descending caisson, and winding up the ascending one, carries them to a relative position opposite to that from which they started; and they are stopped at the proper point by the top of the cross bearers, E, coming in contact with the bottom of the chain carriage, B. The caisson which has been raised from the lower level is then moved, as before, by means of the railway, across the bank of the canal, and suspended over the upper branch; the clutch is then ungeared, the power again applied to the shaft carrying the cams with the balance weight, and the caissons are simultaneously lowered to the bottom of the canal, and the boats floated over their ends and away to their destination.

Various plans for passing boats from one level of a canal to another, by vertical lifts, have been proposed, and some partially carried out in practice. In most of these, however, there is a loss or consumption of water from the upper ponds of the canal in excess of that consumed, or in diminution of that supplied, in passing the upward or downward trade respectively. It will be obvious that the plan above proposed occasions no waste of water; that in passing the upward trade the water consumed is equal to the tonnage of the ascending trade; and in the opposite direction, the water supplied to the upper ponds of the canal is equal to the tonnage of the descending trade; so that a weight of water equal to the whole downward tonnage will be absolutely transferred from the lower to the higher levels of the canal.

The difference of the levels of the two branches of a canal to which this Equilibrium Lift may be applied, is limited only by the strength of materials and convenience of working.

In the present system of Locks, the amount of traffic on canals is really limited to the supply of water, and this in many cases is deficient for the ordinary traffic; so that any reduction of the present rates of carriage on canals becomes hopeless under the present system. But by the adoption of such a system as the one proposed, on the summit levels of canals, their capacities for traffic may be so increased as to enable them successfully to compete with the Railway system, which now threatens to swamp three fourths of the canal property in the kingdom.

This Equilibrium Lift may be made single or double. In its double form, as shown in the drawings and model, it is estimated that it would pass one boat up and another down in about three to five minutes, according to the height of lift.

The value of this lift is its capacity for an almost unlimited amount of traffic, without any expense of water, instead of incurring the constant loss that attends the present locks, amounting to more than 100 tons of water each time that a boat passes through. The enormous annual expense of water to replace the loss by the locks, on many of the canals in the Midland districts, is too well known to those acquainted with their practical working to require any

observation. Supposing the proposed plan applied in several parts of the surrounding district, where there are from 16 even to 30 locks situated close together, and the loss of time to every boat in passing the series of locks is from 2½ to 5 hours, a most important saving of timo would be effected; as, with one and two lifts respectively in those cases, tho whole time required for a boat to pass would be only from 10 to 20 minutes.

It is of course impossible to calculate the expense of the lift for the various heights, without knowing the exact position, but it is considered that for a height of about twenty-one feet, or three ordinary locks, the lift would be as cheap as locks. For a less height the comparative expense would be greater; but for a greater height, within reasonable limits, the lift would be considerably cheaper than locks. In cases where it might be desirable to transfer the boats through a great height, they might be passed at one lift through a shaft into a tunnel below, at any depth that might be required.

The CHAIRMAN illustrated the action of the lift by a large working model. He observed, that in former plans for lifts there was danger of the boat suddenly striking the surface of the water, with the momentum of descending, but that was not possible in the present plan: the boat was necessarily stopped before reaching the surface of the water, and it was then lowered into the water gradually by a second movement. The boat was completely guided into its situation over the caisson; and there was no danger of the boat going wrong in working the lift; even if a boat happened to be caught by the top of the caisson in lifting, no damage could be done, as the man would not be able to lift it, having only power enough to overcome the friction of the apparatus. In this plan, there was no risk of loss of water from carelessness or accident; but, in some plans, where the end of the canal was closed by a sluice, a boat striking the end, by coming

in too fast, might do serious injury, and risk the loss of the water in that section of the canal.

Mr. MABSON enquired what would be the probable expense of the lift?

The CHAIRMAN replied, that the expense of locks might be estimated at about £1,000 each; and for a height of three locks, or 21 feet, the cost would be about £3,000, and the lift would be about the same; but the higher they went with the locks, the better would his plan be suited, and the saving proportionally greater, as most of the expense of the extra locks would be saved. He observed that his object was to show the applicability of the lift, leaving those interested in canals to judge of its advantages.

A vote of thanks was passed to the CHAIRMAN for his paper, and the discussion adjourned.

The following paper, by Mr. S. H. BLACKWELL, of Dudley, was then read:—

ON AN IMPROVED MINER'S SAFETY LAMP.

The Improved Safety Lamp, which is the subject of the present paper, is the invention of Mons. F. Eloin, Mining Engineer, of Belgium.

A visitor to the Exhibition of 1851, he brought over this Lamp with him, for the purpose of introducing it to the notice of the principal mine viewers of this country; and it thus becomes of additional interest, as being one of those contributions of the practical science of the Continent to our own manufactures which have already resulted from the Exhibition, and which will doubtless add much to our own future progress.

Important as was the discovery by Sir Humphrey Davy, of the property possessed by thin wire gauze to prevent the passage of

flame, (and it is scarcely possible to over-estimate the merit of this discovery,) yet it could hardly be expected that the details of any arrangement embodying this principle could be at once made perfect. Attempts to improve the structure of the original Davy Lamp have therefore been numerous, but few of them have been generally adopted, and in most of our collieries the original form of lamp is still used.

The principal defects of the common Davy Lamp are :—

First;—Deficient light, rendering the collier always unwilling to use it, unless compelled by the presence of a highly explosive atmosphere.

Second ;—Liability of injury to the gauze of the cylinder, either by a blow from a pike, a fall to the ground, or otherwise.

Third ;—The possibility of a current of explosive atmosphere being carried through the gauze cylinder, either by the swinging of the lamp in the hand of a person when walking, or by its being exposed to the powerful *blowers of gas*, which are sometimes given off with great force.

Fourth ;—The heating to redness of the gauze, by which explosions actually take place, not from the passage of flame through the gauze, but by the actual contact of the explosive atmosphere with the heated wire. This danger is often increased by the presence of small particles of coal dust, which, floating in the air of the mine, attach themselves to the gauze ; and also from the deposit of *soot on the gauze*, arising from the imperfect combustion of the oil, which in the common Davy Lamp always gives off a dense column of smoke.

In the improved Lamp of M. Eloin (shown in Fig. 8, Plate 43) all these defects are obviated.

First ;—in reference to light. The cylinder, A B, above the flame, is closed, and air admitted only *below the flame*, through a narrow breadth of gauze, C ; but the air which is admitted is brought into actual contact with the flame, by the application of the cap, D, on the principle of the *solar lamp ;* and thus perfect combustion is produced, giving off light equal to at least five or six ordinary Davy Lamps. The light produced is one which the collier

would prefer to that of any candle, from its greater intensity. From the perfect combustion of the oil, no *smoke* whatever is given off.

Second ;—As to the liability of injury to the gauze. This is obviated by using, first, a strong short cylinder of glass, A, through which the light passes, capped above the flame with a brass or iron cylinder, B, which cannot be injured, except by actual violence. It might be supposed that the glass portion of the cylinder would be liable to accident, but in practice this is not found to be the case: bound, at top and bottom, by a strong brass ring, if it were even to crack, either from a blow, or from unequal expansion by heat, no danger would result, as the pieces into which it would be separated would still be held together with the brass beadings.

Third ;—The closed nature of the cylinder entirely prevents the passage of an explosive atmosphere into the lamp, by any current of air; no swinging of the lamp causes any action on the flame; and no blower of gas can blow into the flame, in consequence of the protection of the cylinder.

Fourth ;—All danger by the heating to redness of the wire gauze is entirely removed.

In addition to the entire removal of the defects of the common Davy Lamp, the Lamp of M. Eloin possesses, from its structure, some peculiarities that render it much safer.

The air which enters through the narrow breadth of wire gauze, *below the flame*, being only such as is necessary to support the flame of the wick, and the combustion being of so perfect a character, that portion of the cylinder which is above the flame must always be filled with the products of combustion, and never with an explosive atmosphere. In the ordinary Davy Lamp there must always be a tendency in the surrounding atmosphere to rush through the wire gauze into the lamp, and to fill it, more or less, with the atmosphere of the mine, whatever that may be. In M. Eloin's Lamp the contents of the cylinder above the flame must always be the products of combustion. This is clearly seen by the flame being extinguished whenever the general upward current is by any means reversed. So confident is M. Eloin of the action of his

lamp in this respect, from his experience in the Belgian mines, that he has placed a very coarse wire gauze over the top of the lamp, simply for the purpose of preventing any particles of coal or dirt from entering, but of a width that would readily allow the passage of flame, if any flame could be supported in the upper part of the cylinder.

The weight of the lamp (always an important consideration where it has to be carried for any length of time in the hand) is not at all objectionable.

It is not expensive in its structure. A lamp as highly finished as that now before the meeting costs in Belgium about 7 francs.

The power of perceiving the presence of gas, by the ordinary elongation of the flame, is fully equal in *this* lamp to that of the ordinary *Davy* lamp.

A conical brass shade, E, is attached to, and made to slide upon, the rods surrounding the glass portion of the cylinder, by which the light can be directed downwards if wished, so as to throw the light over the floor of the mine, when the shade is moved up, as shown by the dotted lines at F.

Combining, then, as this Lamp undoubtedly does, all the advantages, and, at the same time, obviating the more important defects, of the ordinary Davy Lamp, the author of the present paper cannot but think that it must ultimately come into general use; and that great praise is due to its inventor, M. Eloin, for the liberality with which he has thrown it open to the English mining public, without limiting its use by any patent or other restriction. He knows from the inventor personally, that nothing will give him greater pleasure than to hear of its general adoption in our collieries, and he cannot but regard its introduction amongst us as a good omen of the results which, we may hope, will arise hereafter from the more cordial intercourse between the practical science of England and the Continent, arising out of the Exhibition of 1851.

Mr. BLACKWELL exhibited one of the improved lamps, and an ordinary Davy lamp, both lighted, and said he had taken special care to trim the old lamp well, but the improved lamp gave five or six times the light; and from the perfect combustion of the oil, no smoke was thrown out, whilst in the other lamp there was a great quantity of smoke. He observed that the glass could not be injured, except by actual violence, and that with difficulty. He had that morning dropped the lamp from some height upon a hard stone pavement, and it remained uninjured. He knew of cases that had occurred, where the wire gauze of the ordinary lamp, or perhaps the particles of coal dust in the meshes of the gauze, had become so intensely heated as to inflame the surrounding gas, even from the circumstance of the lamp lying inclined, so that the flame heated the gauze on one side; but such accidents were effectually prevented with the new lamp.

Mr. CLIFT recollected seeing a lamp that was brought out several years ago, which he thought bore a great resemblance to M. Eloin's lamp. It was, he believed, invented by Mr. Roberts, of Bilston, the original inventor of the solar lamp; it was on the solar principle, and so far similar to M. Eloin's lamp, but it had a glass cylinder the whole length of the lamp; it was first made with both a glass and a gauze cylinder, but afterwards glass only was used.

Mr. BLACKWELL believed that he had seen Mr. Roberts's lamp, but he was not fully acquainted with it. The long glass cylinder would be a great objection, and very liable to be broken and cause explosion. The glass cylinder of the lamp now introduced was not, he thought, at all objectionable; it was very strong and short, and even if many cracks were produced, it would still be bound together by the brass rims at the top and bottom.

The CHAIRMAN observed, there must, he thought, have been some particular objection to Mr. Roberts's lamp, or it would have been more generally used. The lamp of M. Eloin certainly gave

a very superior light to the other, and he thought it was also safer. A crack in the glass would be visible and show itself, but it would not in the gauze of the ordinary lamp.

Mr. CLIFT said there could be no question that the lamp of M. Eloin was much better and safer than the Davy lamp, as there was no wire gauze to heat, and endanger an explosion of gas. It was both safer, and gave a much better light. He supposed that the objection to the use of the lamp of Mr. Roberts was, the great liability for the long glass cylinder to be broken by the men, for he did not hear that it had ever come into general use.

Mr. BLACKWELL observed that he would be glad to make a comparison before a future meeting between the lamp of M. Eloin and any other safety lamps in use in the mining districts.

A vote of thanks was passed to Mr. BLACKWELL for his paper.

The CHAIRMAN announced that the Ballot Lists had been opened, and the following new Members, &c., were duly elected:

MEMBERS:

PETER W. BARLOW, London.
WILLIAM H. BARLOW, Derby.
EDWARD DIXON, London.
HENRY JOHNS, Smethwick.
THOMAS ROBINSON, Brierley Hill.

HONORARY MEMBER:

JOHN DOUGLAS PAYNE, Walsall.

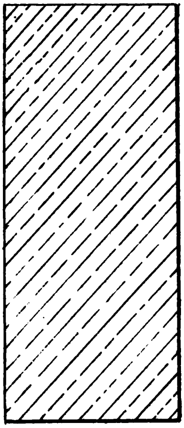
The Meeting then terminated.

BIRMINGHAM: PRINTED AT M. BILLING'S STEAM-PRESS OFFICES, NEWHALL STREET.

RAILWAY CARRYING STOCK.

Sections of Waggon Sole-Bars.

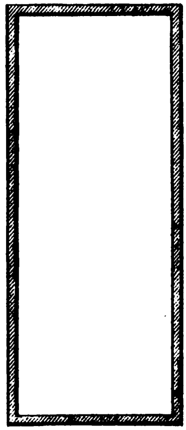
Fig: 1.



Present Oak Sole-bar 321 lbs weight.

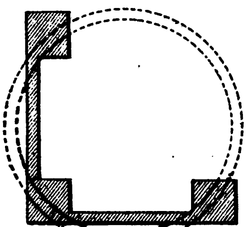
Oak 49½ In. area

Fig: 2.



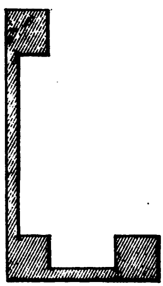
Iron 5 In. area.

Fig. 3.



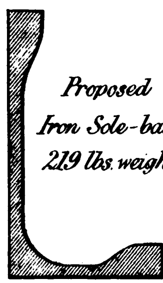
Iron 5 In. area

Fig. 4



Iron 5 In. area

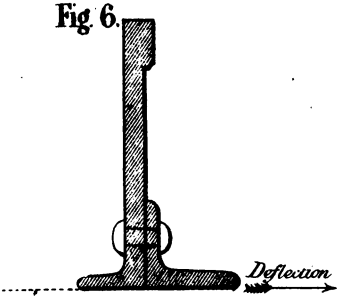
Fig. 5



Proposed Iron Sole-bar 219 lbs. weight

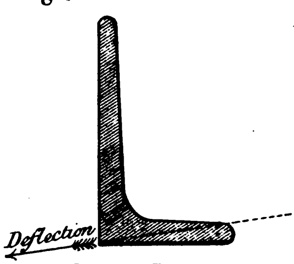
Iron 5 In. area

Fig. 6.



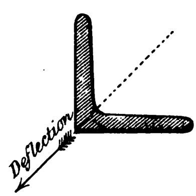
Iron 6½ In area

Fig. 7



Iron 5½ In. area

Fig. 8.



Scale 1/5th size

WATER METER

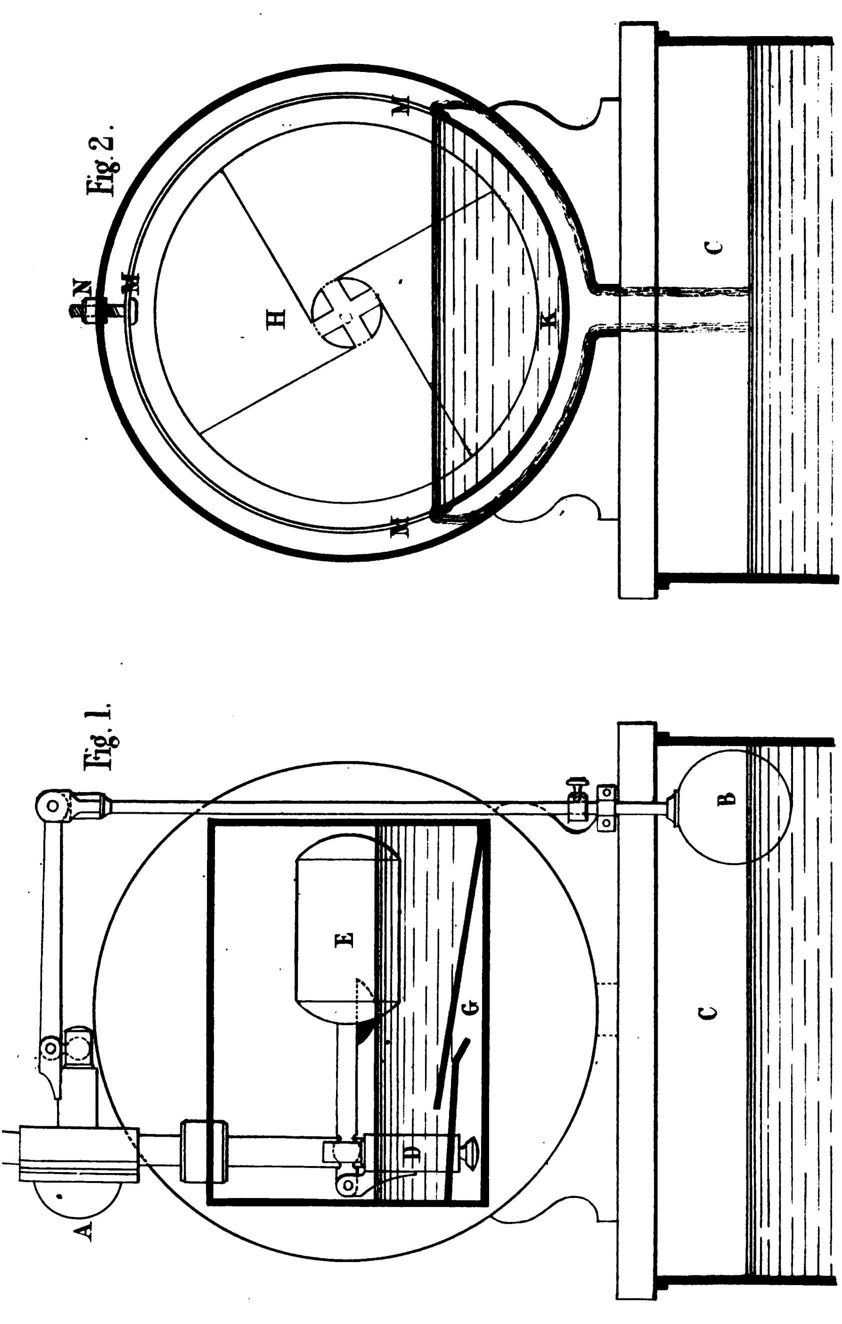


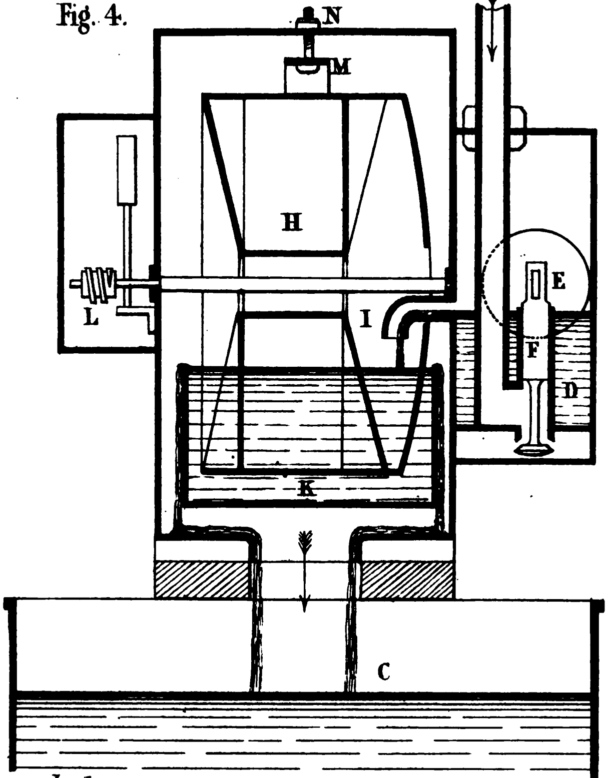
Fig. 2.

Fig. 1.

Scale 1/6th. size

WATER METER

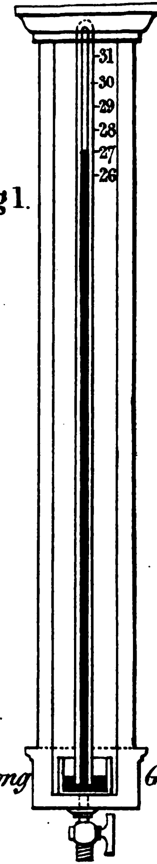
Fig. 4.



Scale 1/6th size

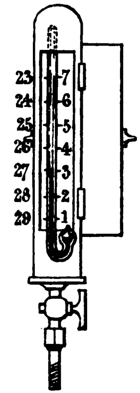
VACUUM GAUGES

Fig 1.



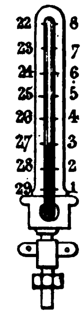
Long Gauge

Fig. 2



Short Gauge

Fig. 3.

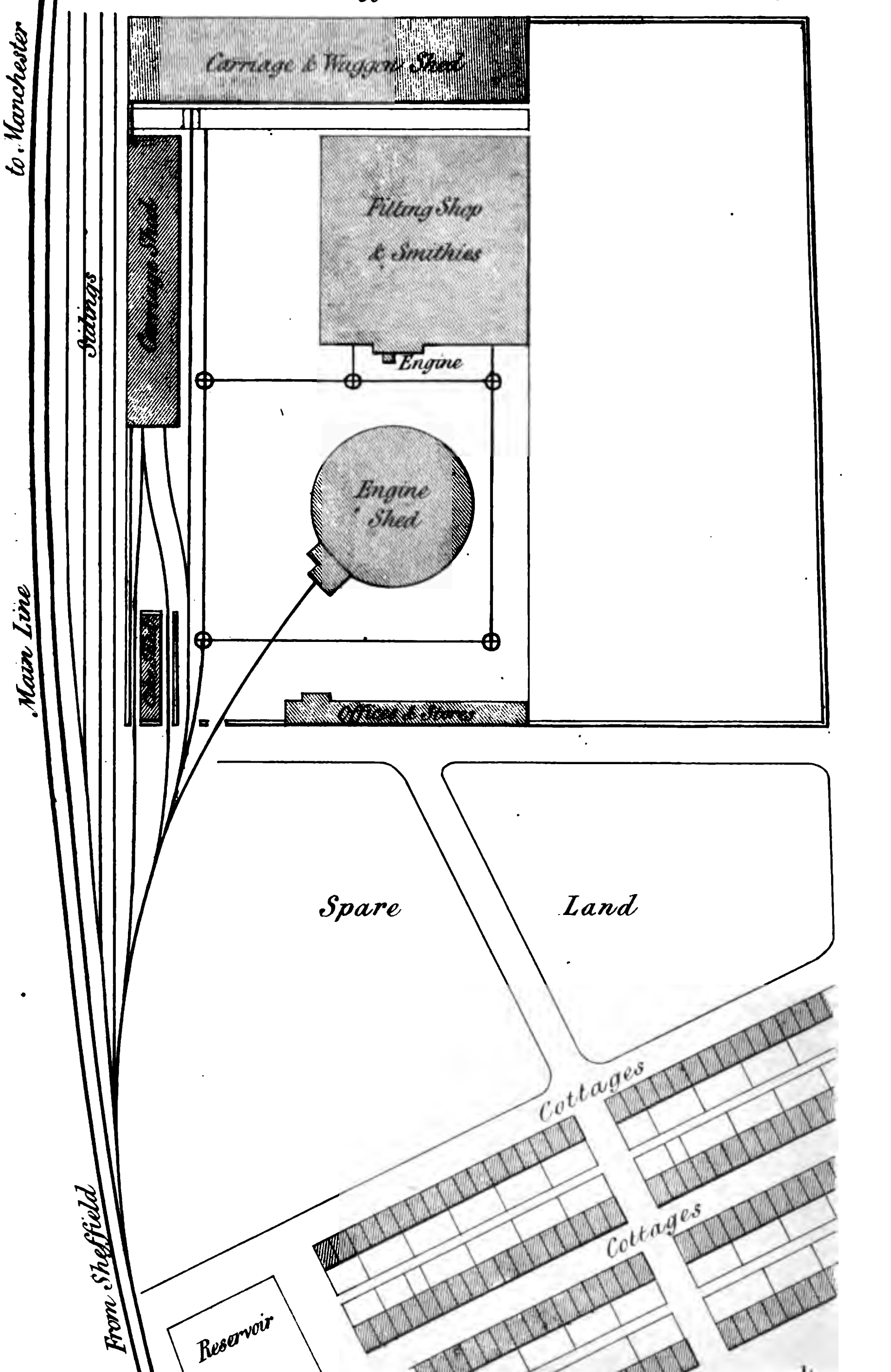


Improved Gauge

Scale 1/8th size

LOCOMOTIVE WORKS.

Manchester Sheffield and Lincolnshire Railway



Scale. 160 feet per inch

LOCOMOTIVE WORKS

Plate 2

Manchester, Sheffield & Lincolnshire Railway

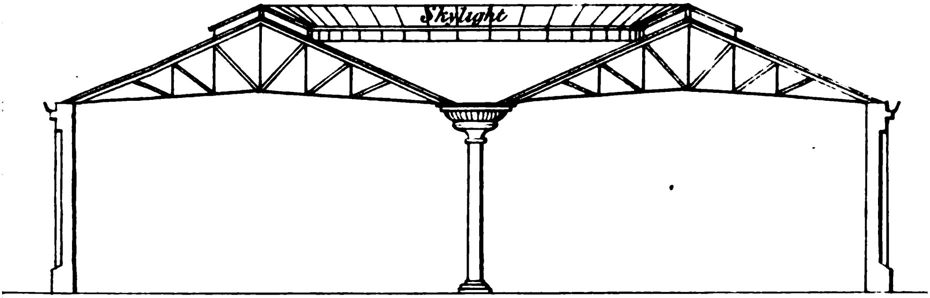
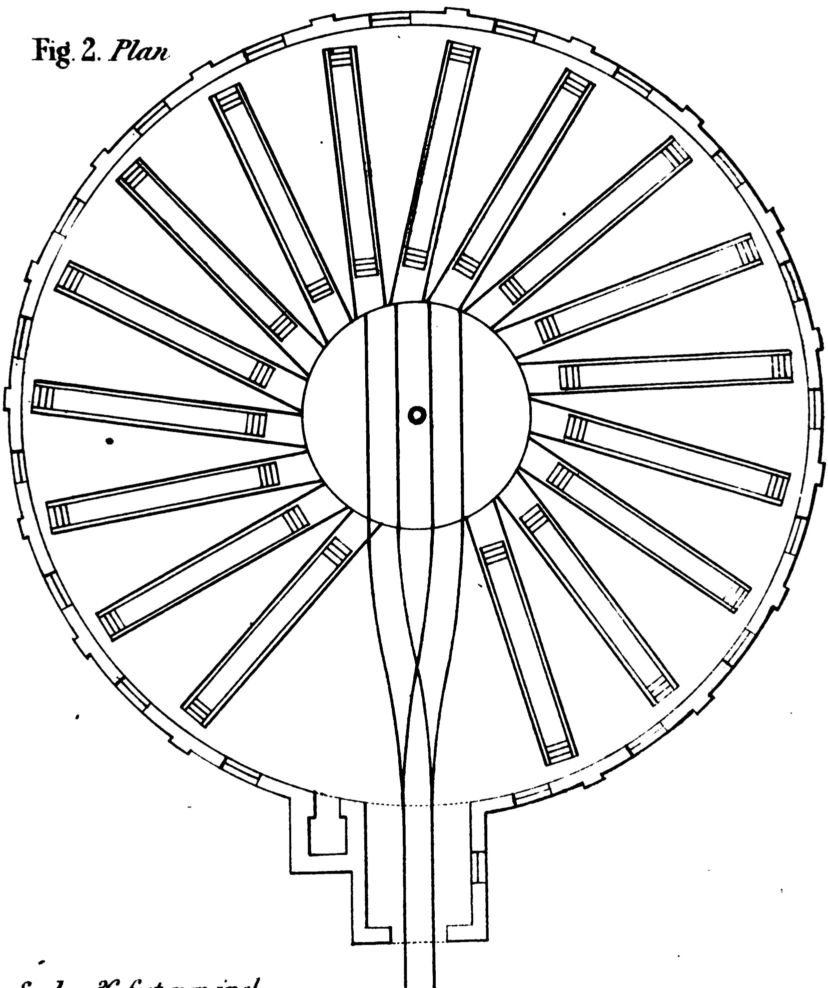


Fig 1. *Section of Engine Shed*

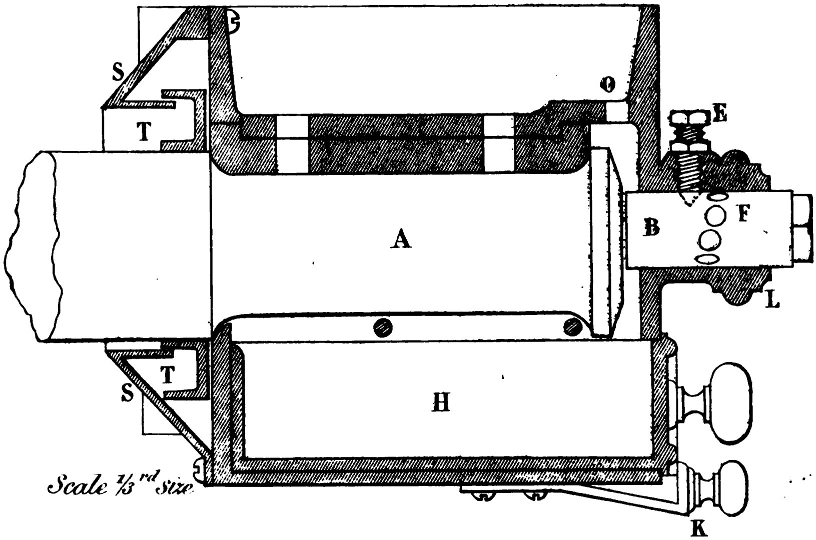
Fig. 2. *Plan*



Scale_36 feet per inch

IMPROVED AXLE BOX.

Fig. 1.



Scale 1/3rd size

Fig. 3.

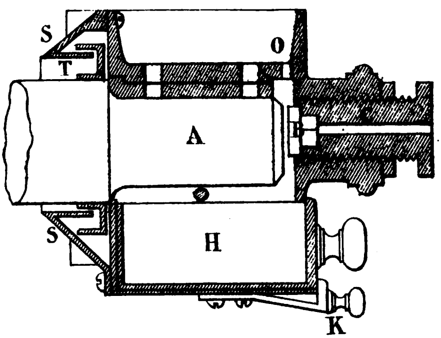


Fig. 2.

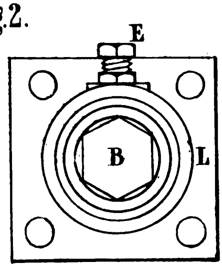


Fig. 4.

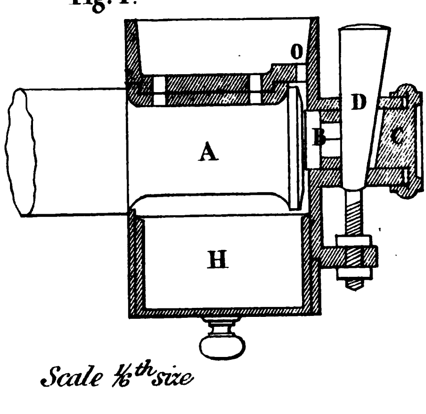
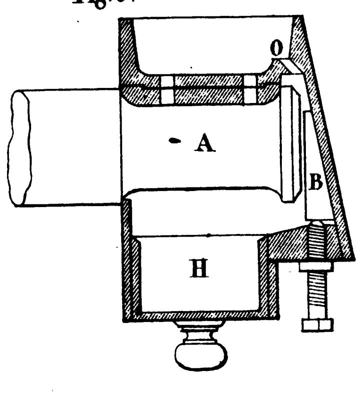


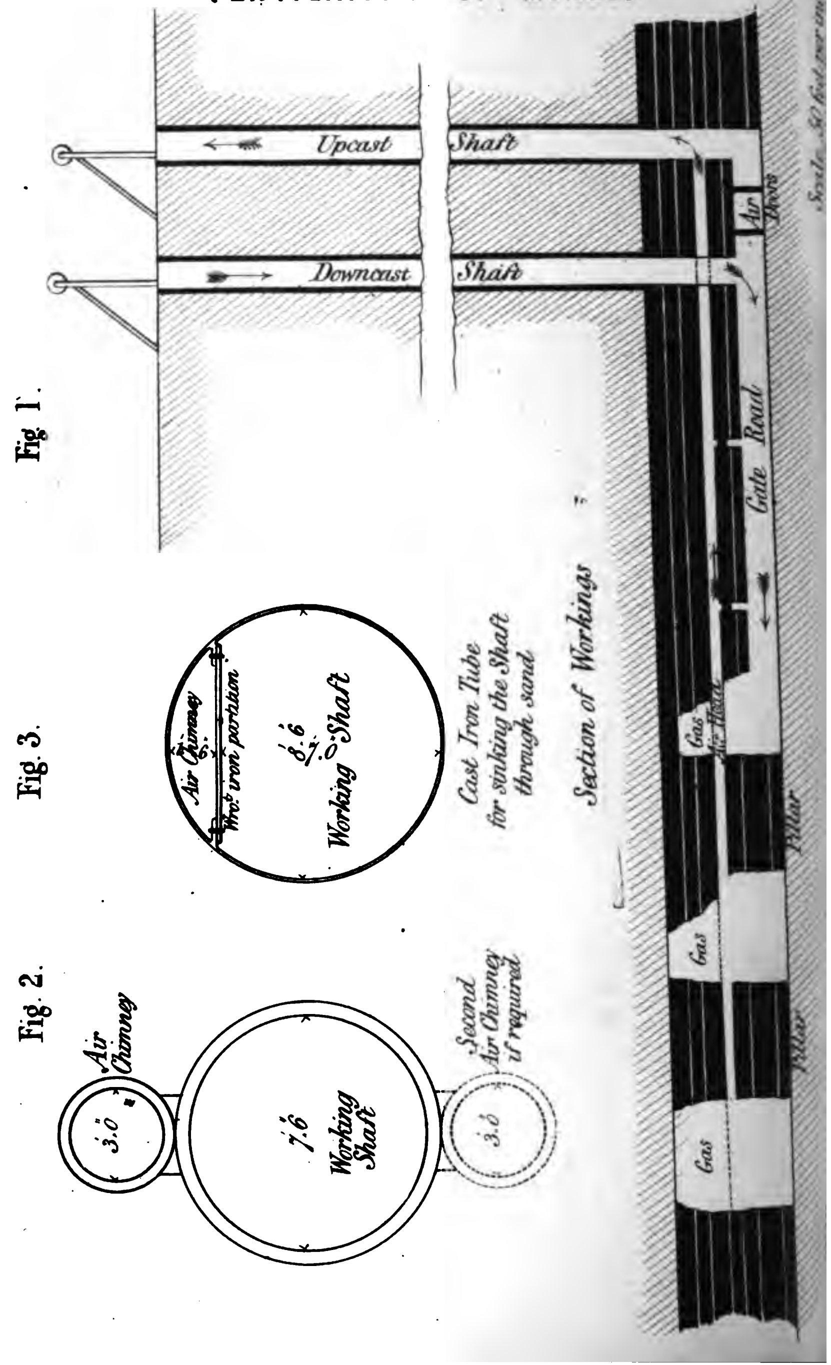
Fig. 5.



Scale 1/6th size

Plate 24.

VENTILATION OF MINES.



VENTILATION OF MINES.

Plan of Workings
in the South Staffordshire Ten-Yard Coal
Shewing the ~~improved~~ ordinary system of Ventilation

The Air-ways are shewn by dotted lines

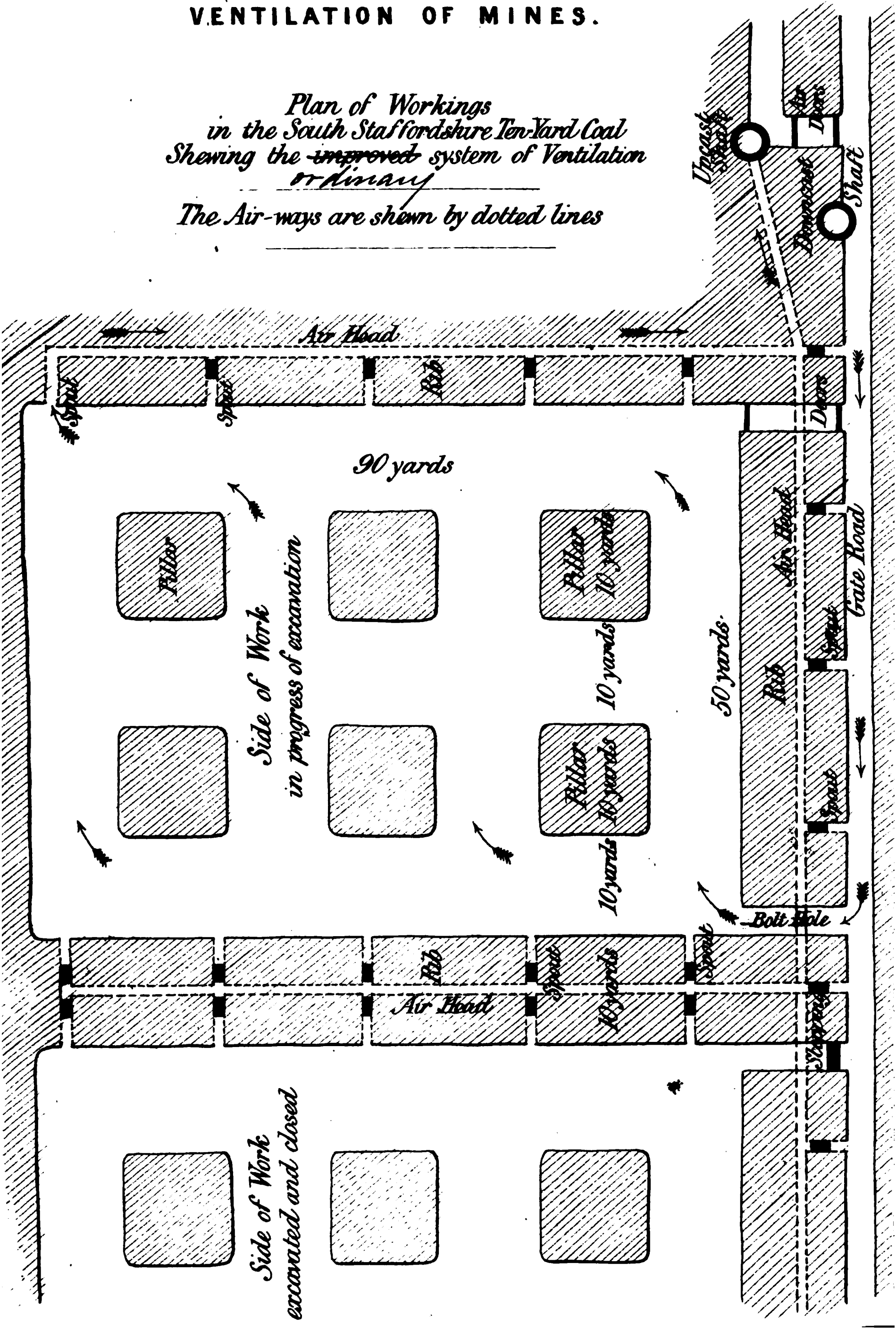
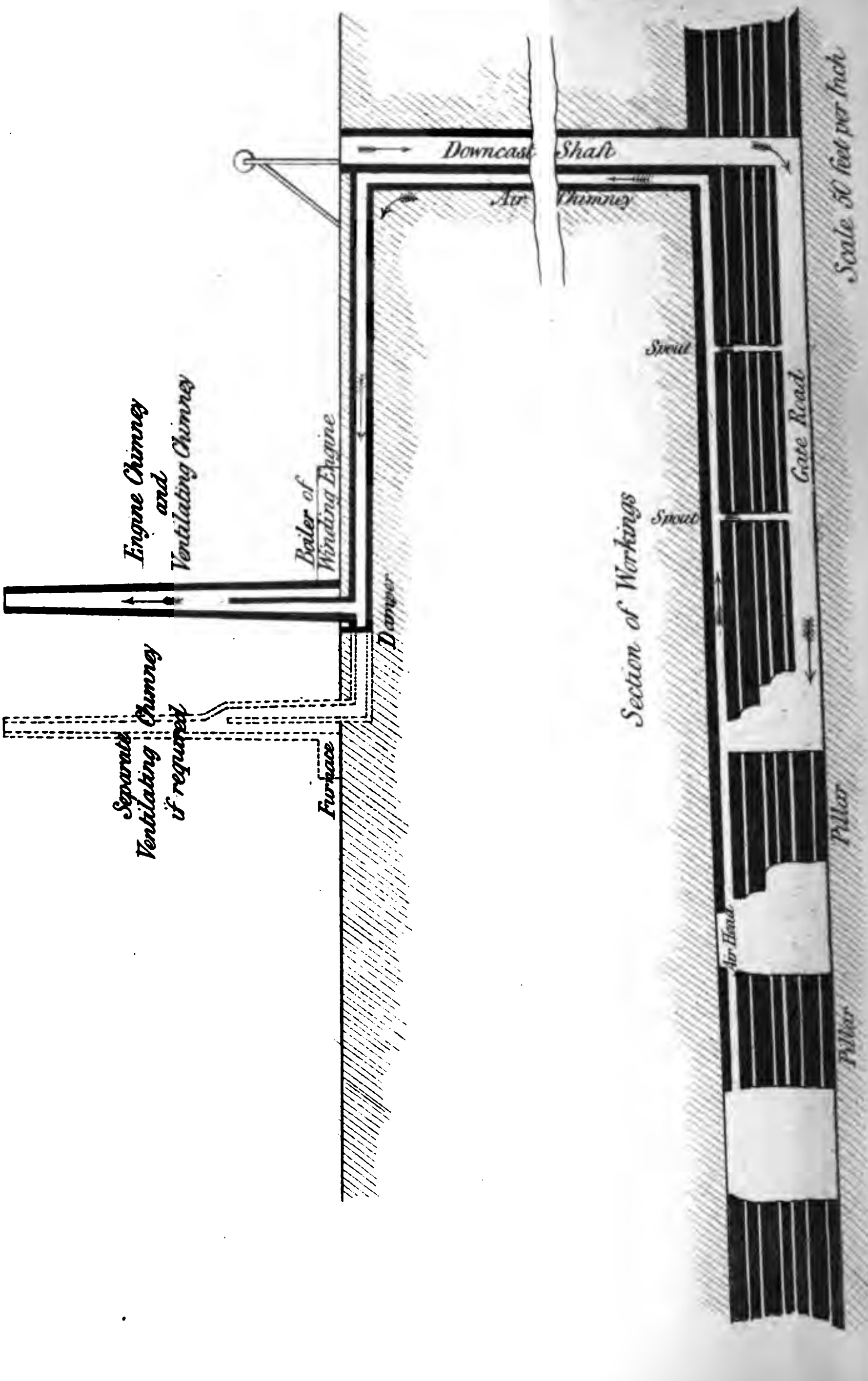
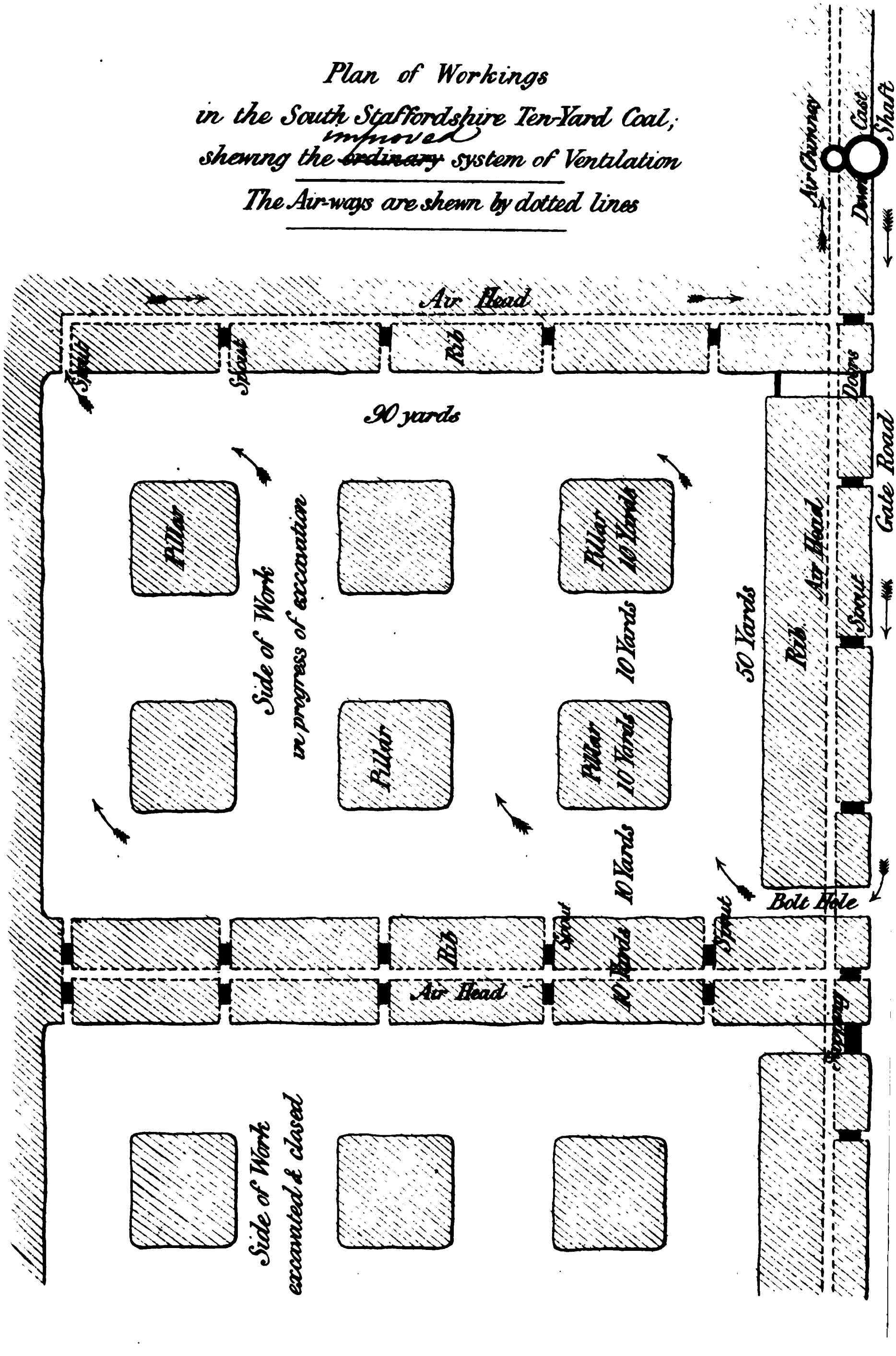


Plate 26.

VENTILATION OF MINES



VENTILATION OF MINES.



Plan of Workings
in the South Staffordshire Ten-Yard Coal;
shewing the ~~ordinary~~ improved system of Ventilation

The Air-ways are shewn by dotted lines

Plate 28.

BLOOMING MACHINE.

Fig. 1.

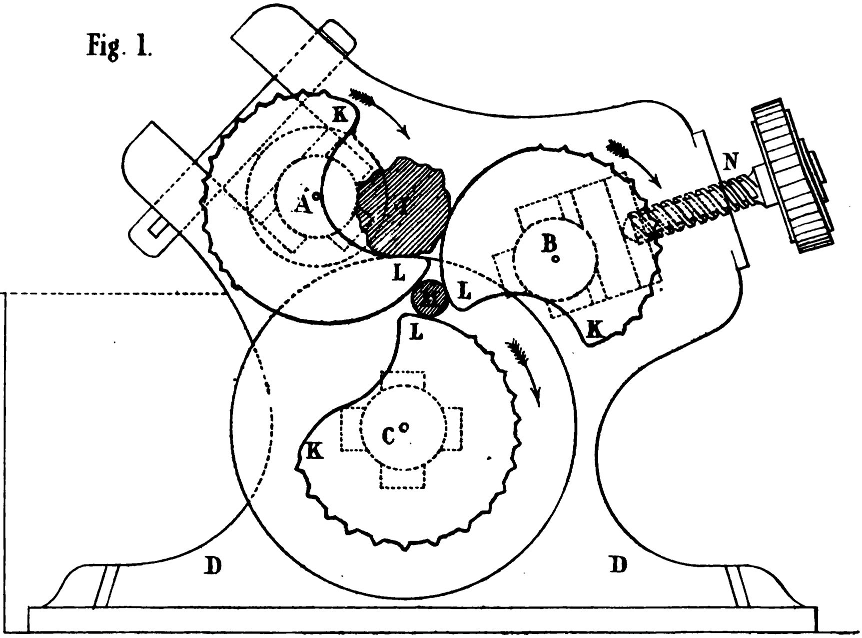
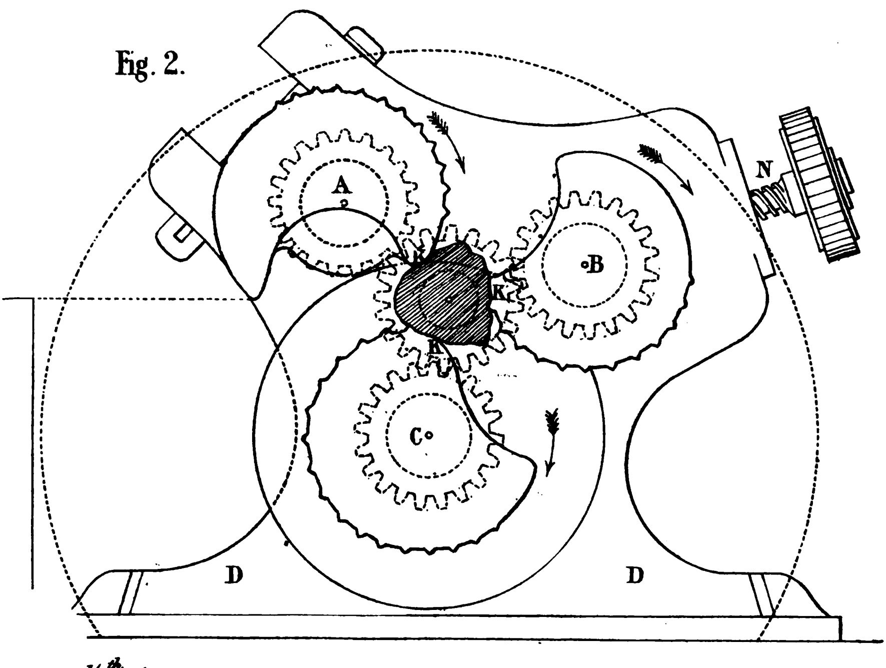


Fig. 2.

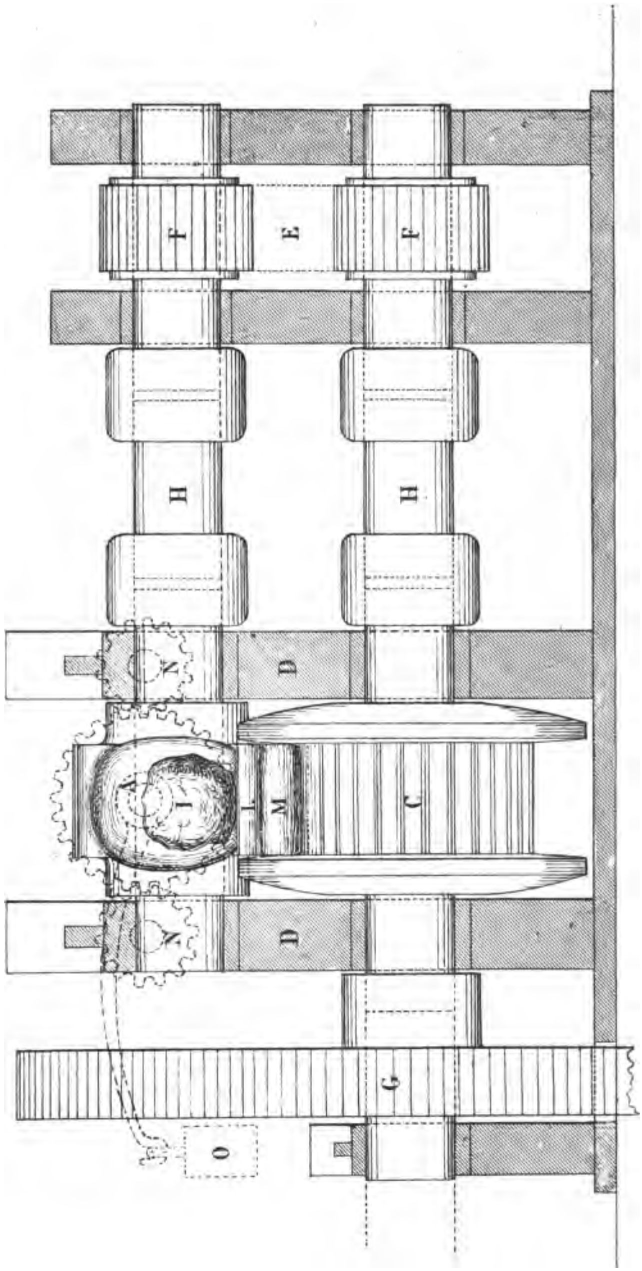


1/26th size.

Plate 29.

BLOOMING MACHINE.

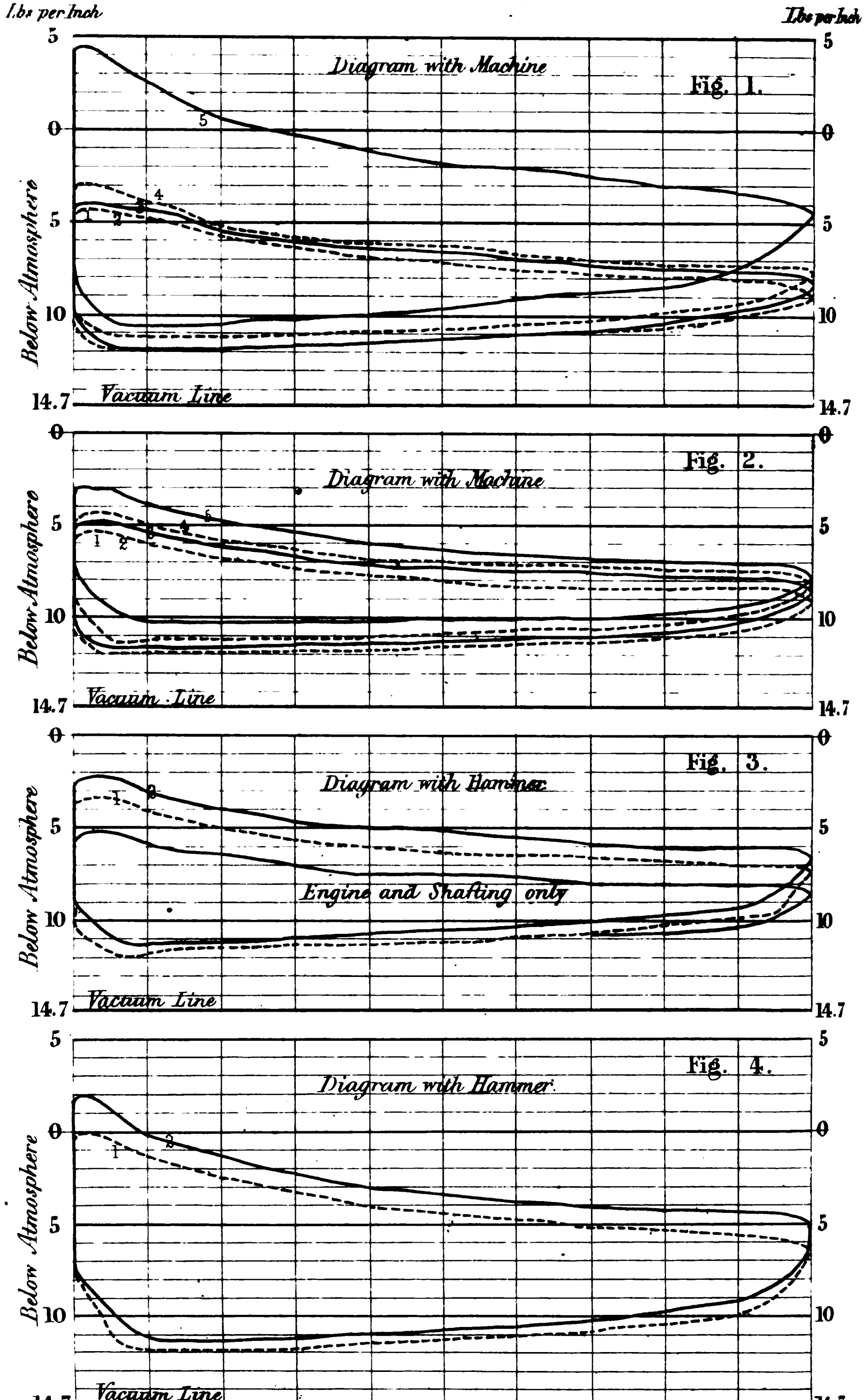
Fig. 3



Scale 1/26th size

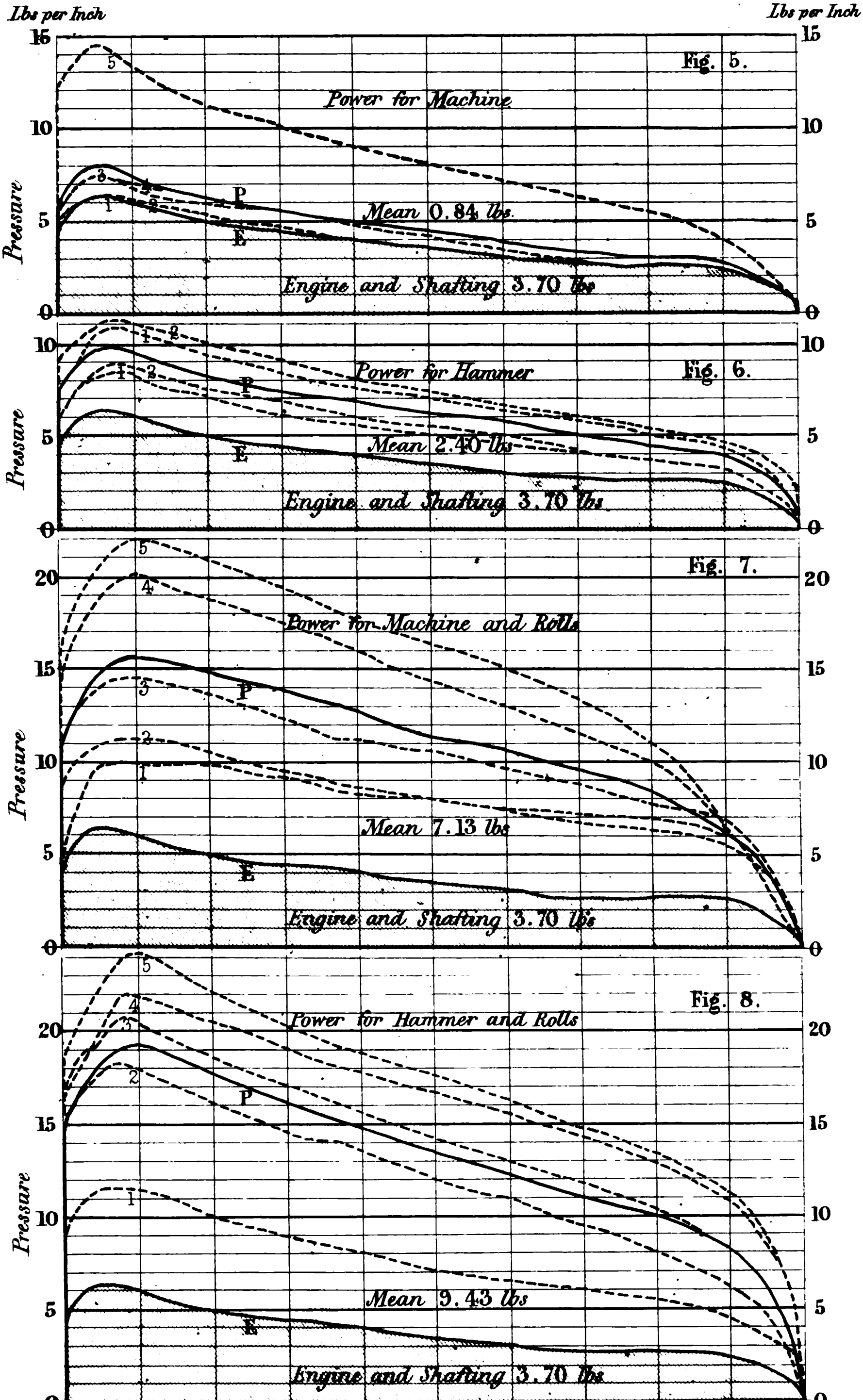
Plate 30

BLOOMING IRON



Waterlow & Sons, Lith, London-Wall, London.

BLOOMING IRON



BLOOMING IRON.

Fig.1. *Section of a defective Bloom from the Hammer, shewing a lap and a hollow containing cinder.*

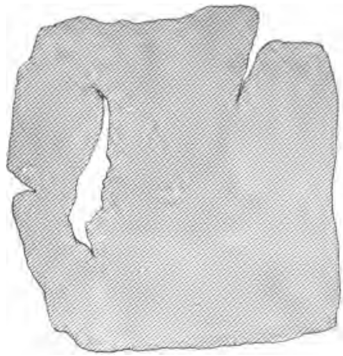


Fig 2. *Section of an ordinary Bloom from the Hammer.*

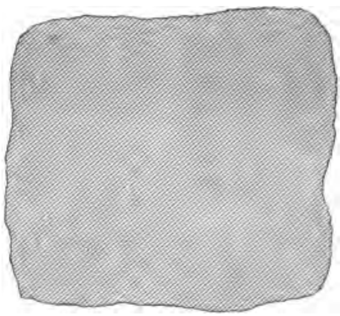
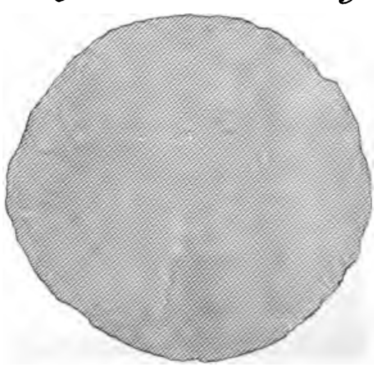


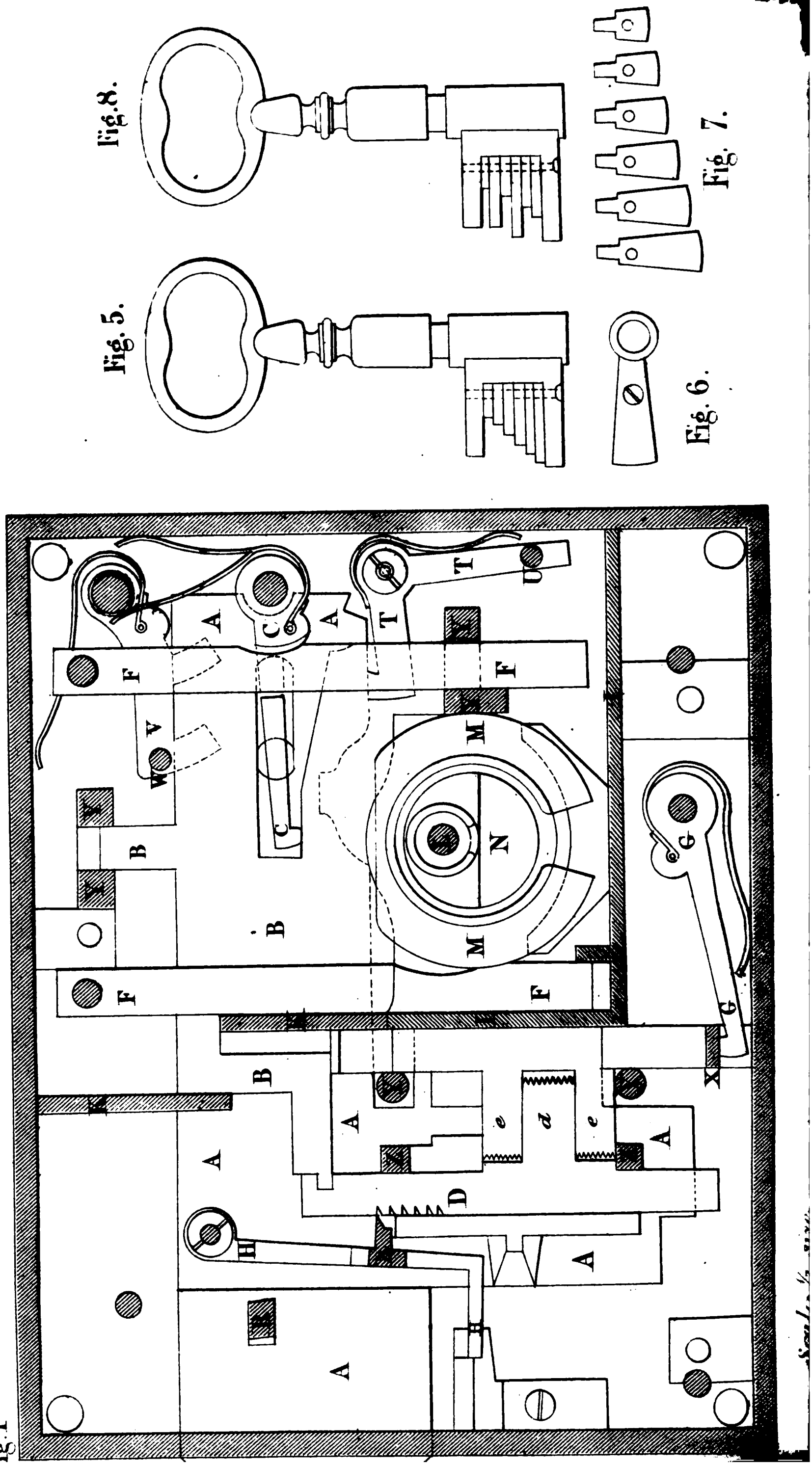
Fig.3. *Section of an ordinary Bloom from the Machine*



Scale 1/3 size

NEWELL'S PATENT LOCK.

Plate 33.



Plan shewing the Bolt unlocked and the Auxiliary-tumbler Detector-plate & Cover removed.

Fig. 1

NEWELL'S PATENT LOCK.

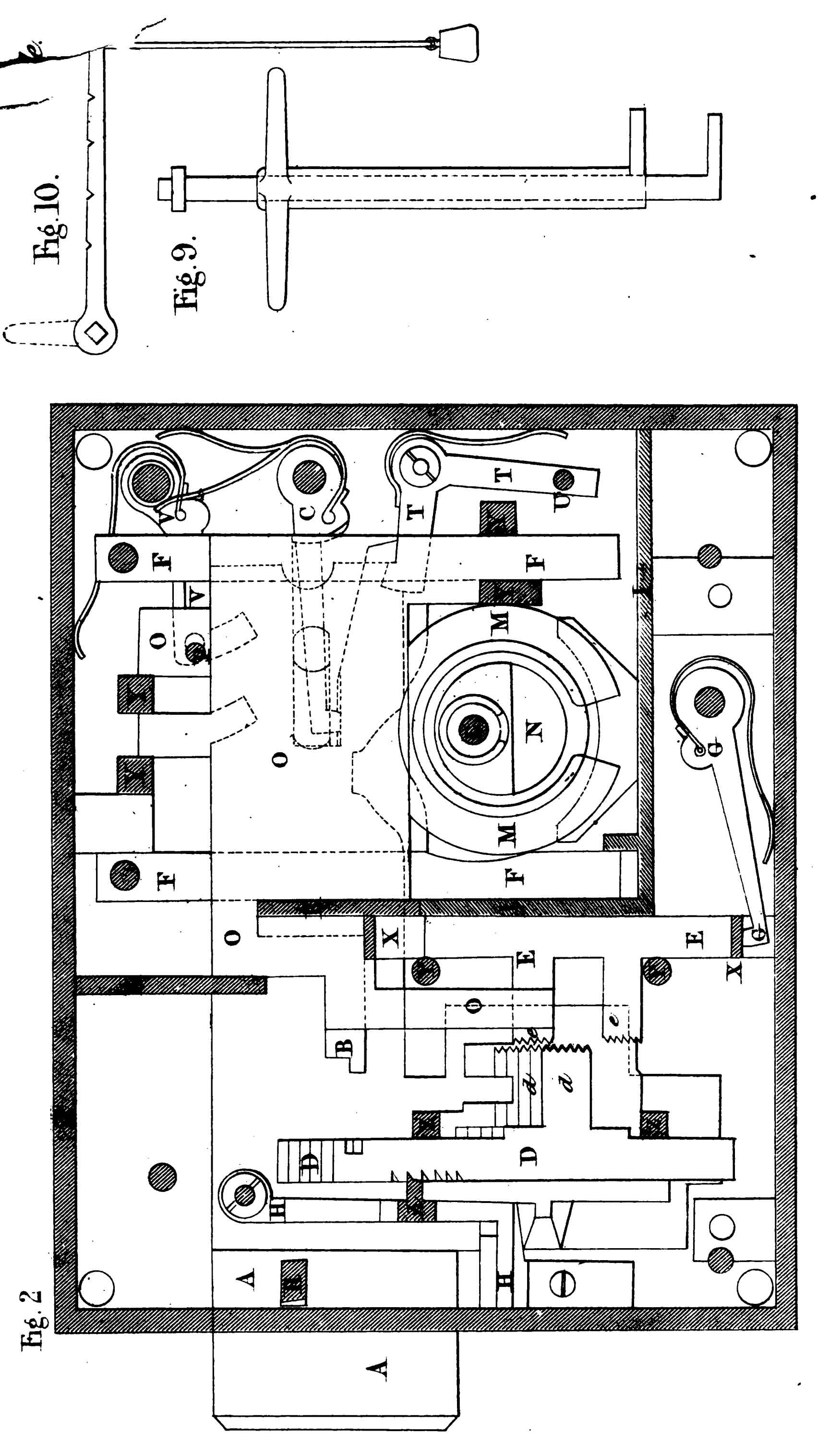


Fig. 10.

Fig. 9.

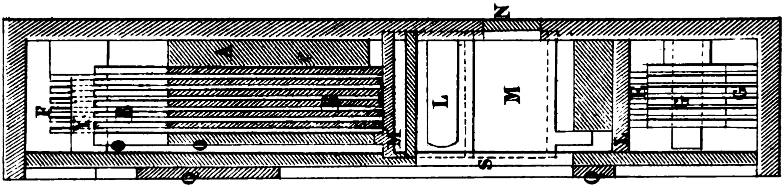
Fig. 2

Plan shewing the Bolt locked & the Detector-plate & Cover removed.

NEWELL'S PATENT LOCK.

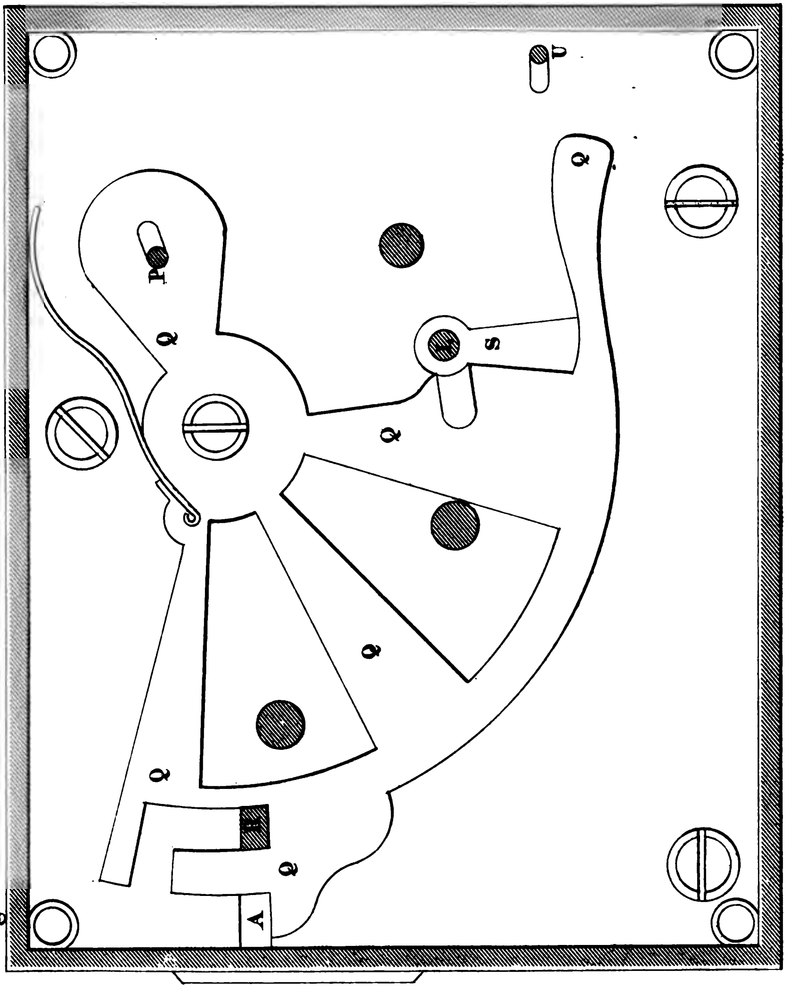
Fig. 4.

Section through the keyhole.



Plan shewing the Detector Plate & Cover.

Fig. 3.



Scale ½ size

RAILWAY WAGGONS.

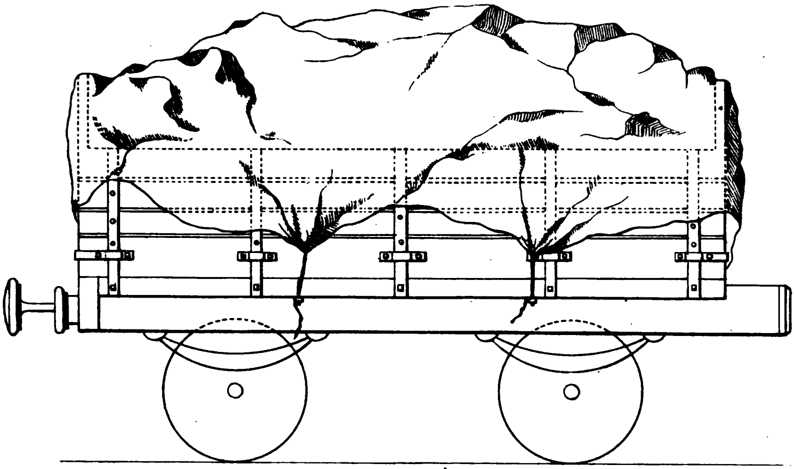


Fig. 1. *Ordinary open Goods Waggon.*

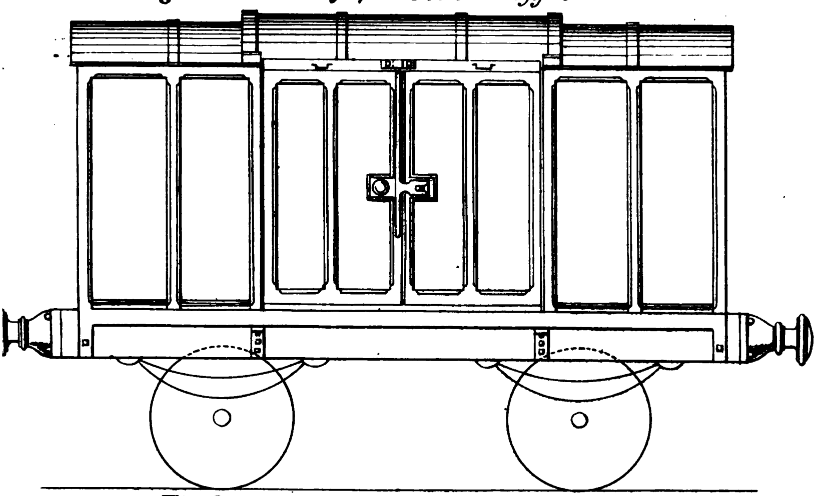
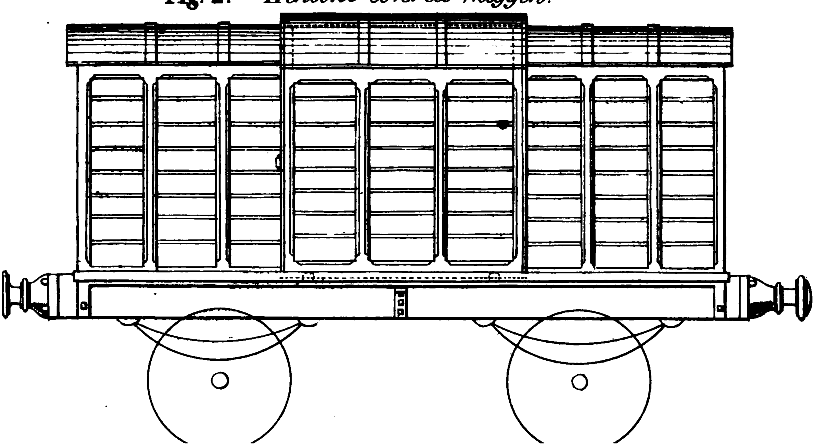


Fig. 2. *Henson's Covered Waggon.*



RAILWAY WAGGONS.

Henson's Covered Goods Waggon.

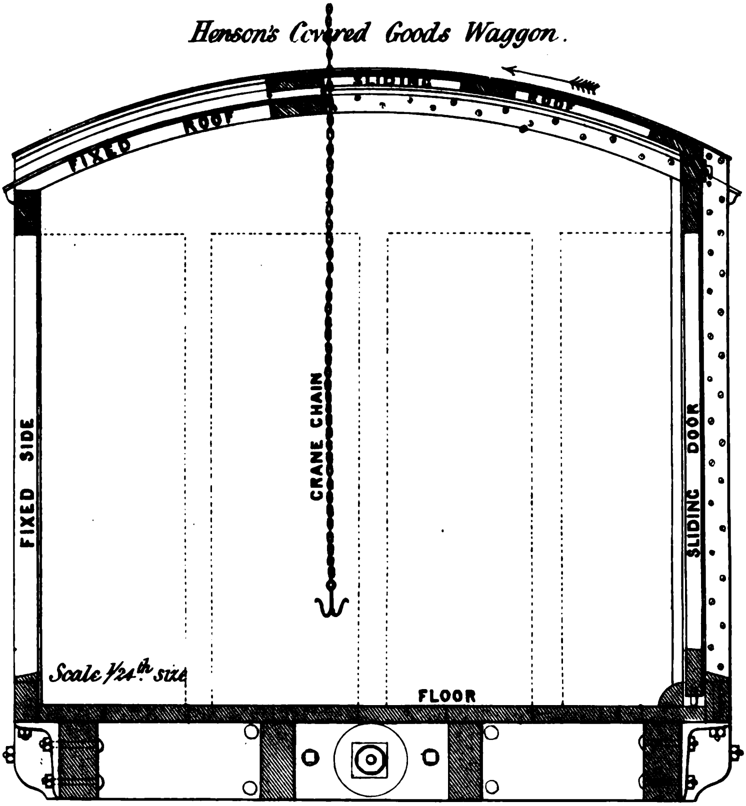


Fig 4. Transverse Section of the Body

Fig. 5. *Sliding Door at the side*

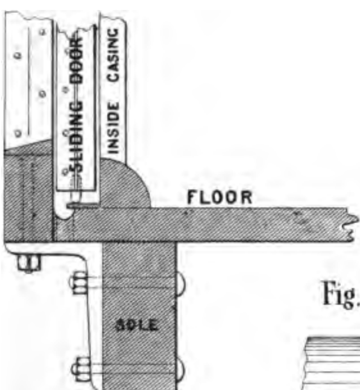


Fig. 6. *Sliding Door in the Roof*

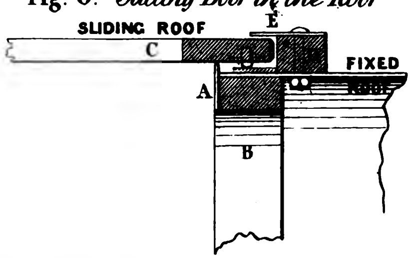
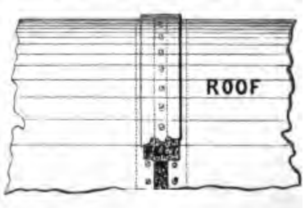


Fig. 7. *Covering of the Roof*



RAILWAY WAGGONS.

Henson's Covered Goods Waggons.

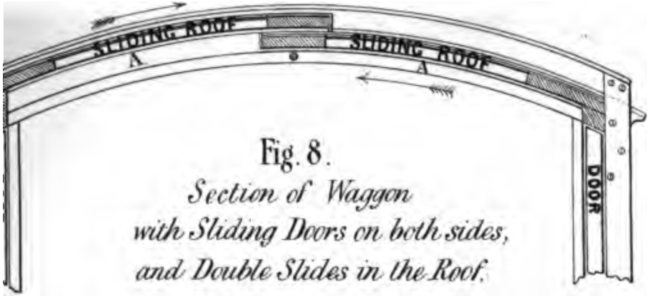


Fig. 8.
Section of Waggon
with Sliding Doors on both sides,
and Double Slides in the Roof.

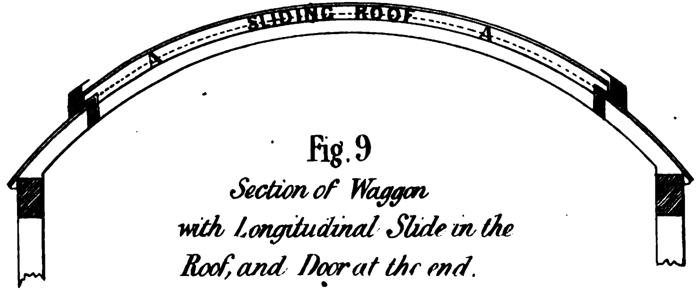


Fig. 9
Section of Waggon
with Longitudinal Slide in the
Roof, and Door at the end.

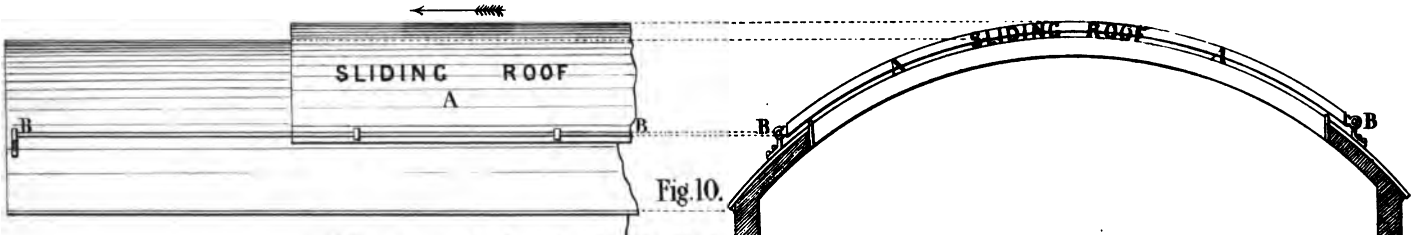


Fig. 10.
Waggon with Longitudinal Slide in Roof, and End Door.

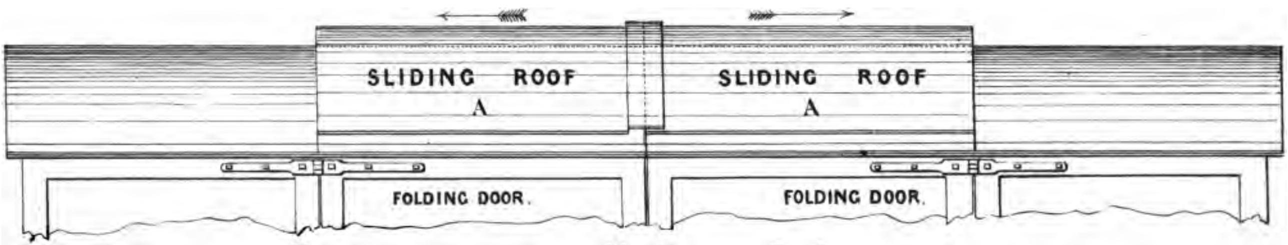


Fig. 11. Waggon with Double Slides in Roof, and Folding Doors.

REGENERATIVE CONDENSER.

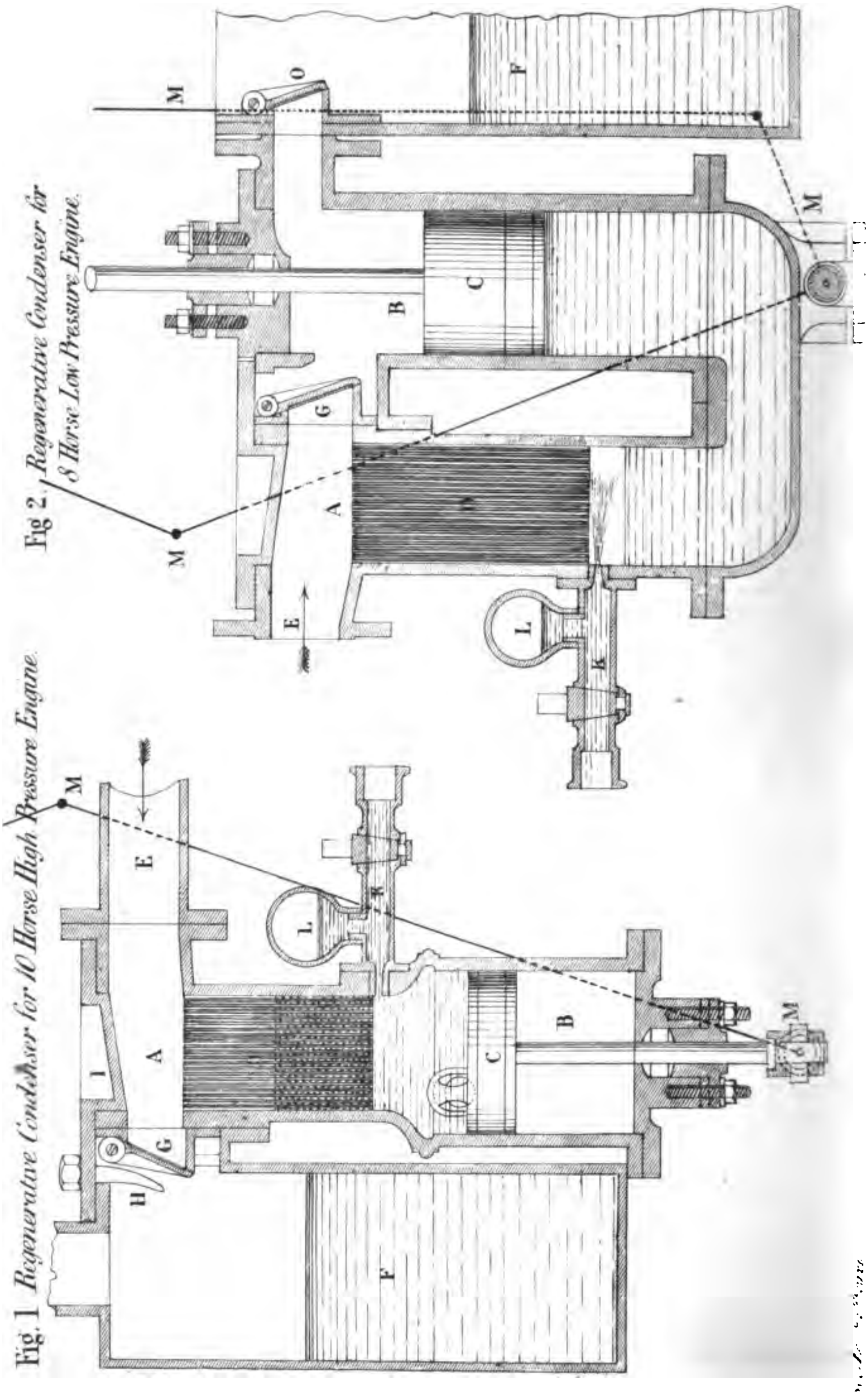


Fig. 1 Regenerative Condenser for 10 Horse High Pressure Engine.

Fig 2. Regenerative Condenser for 8 Horse Low Pressure Engine.

REGENERATIVE CONDENSER.

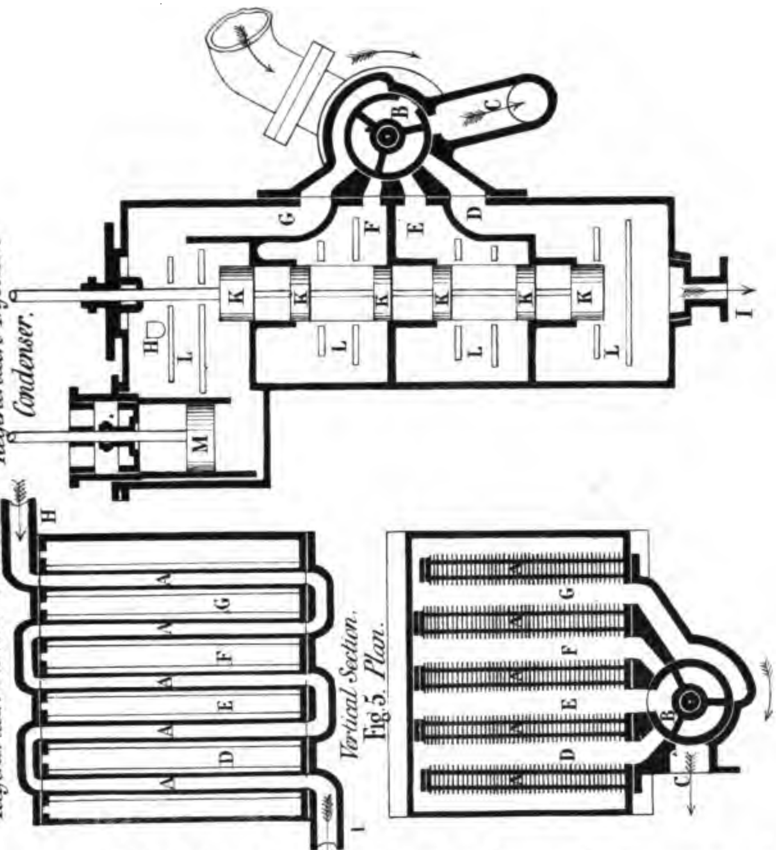


Fig. 6. Regenerative Injection Condenser.

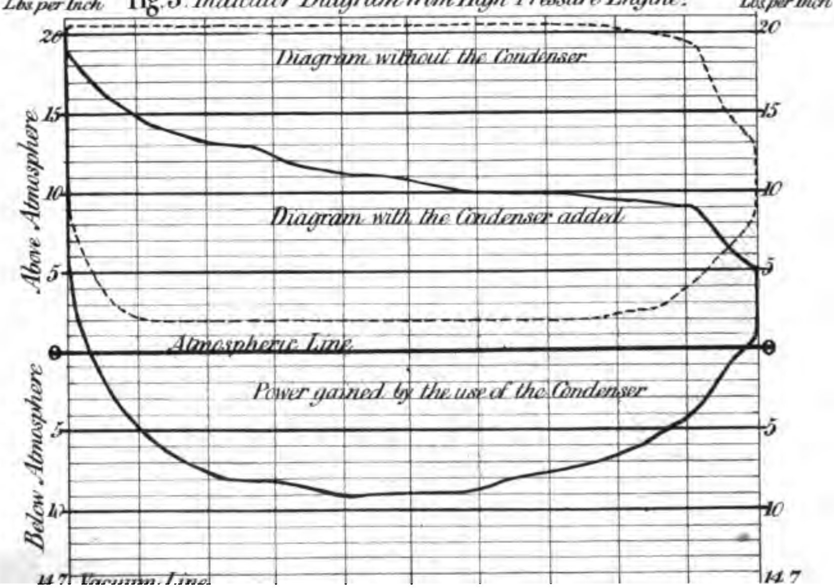
Fig. 4. Regenerative Surface Condenser.

Vertical Section.

Fig. 5. Plan.

Scale 1/6th size

Fig. 3. Indicator Diagram from High Pressure Engine.



COWPER'S RAILWAY CHAIR.

Fig. 1. *Section of Moulding Box.*

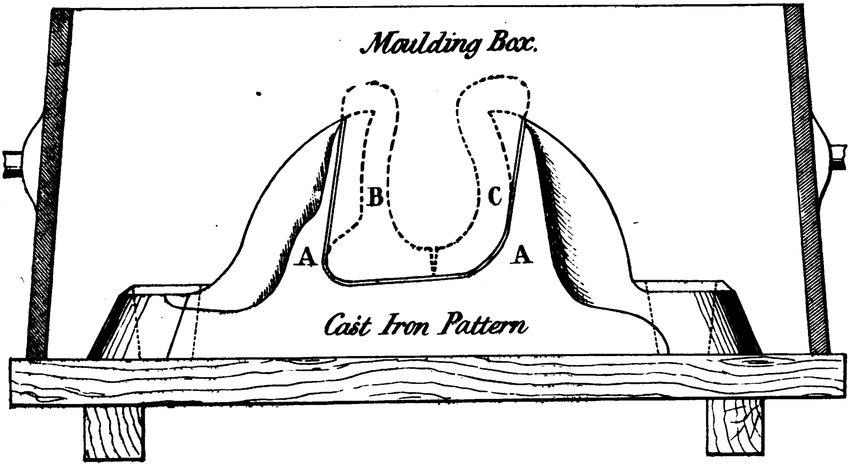


Fig 2. *Chill Plate.*

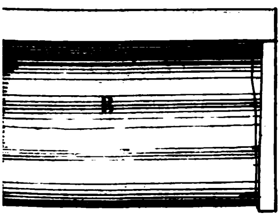


Fig. 4. *Section of Chill Plates.*

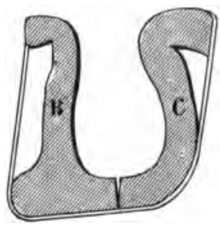


Fig. 3. *Chill Plate.*

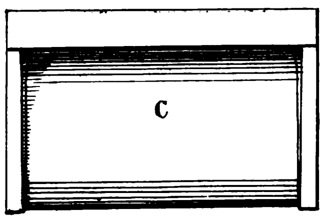
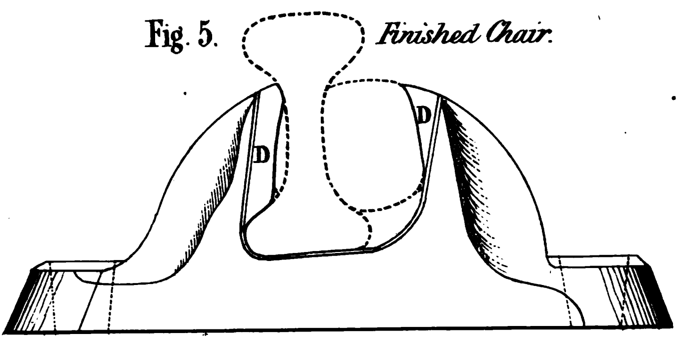


Fig. 5. *Finished Chair.*



Scale ¼th size

Plate 42.

SHIPTON'S PENDULOUS ENGINE.

Fig. 1

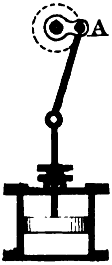


Fig. 2

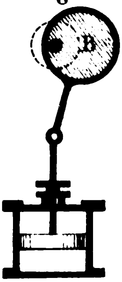


Fig. 3.

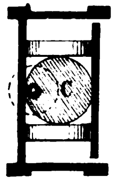


Fig. 4

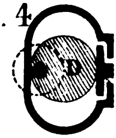


Fig. 5.

Elevation of 20 Horse Steam Engine

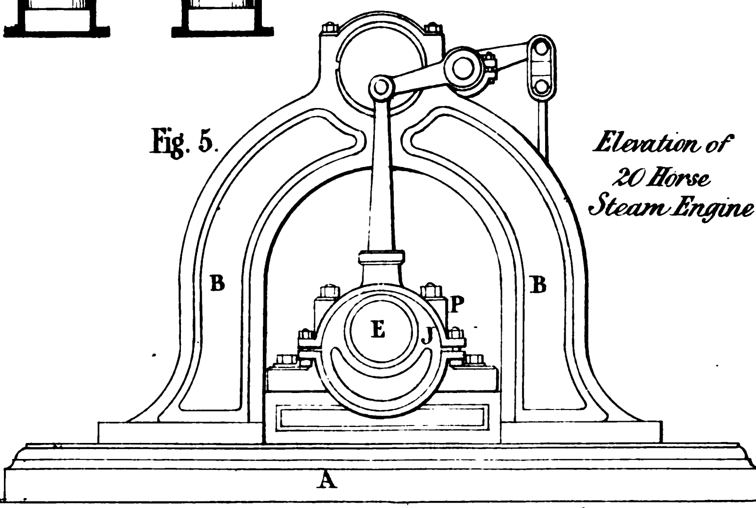
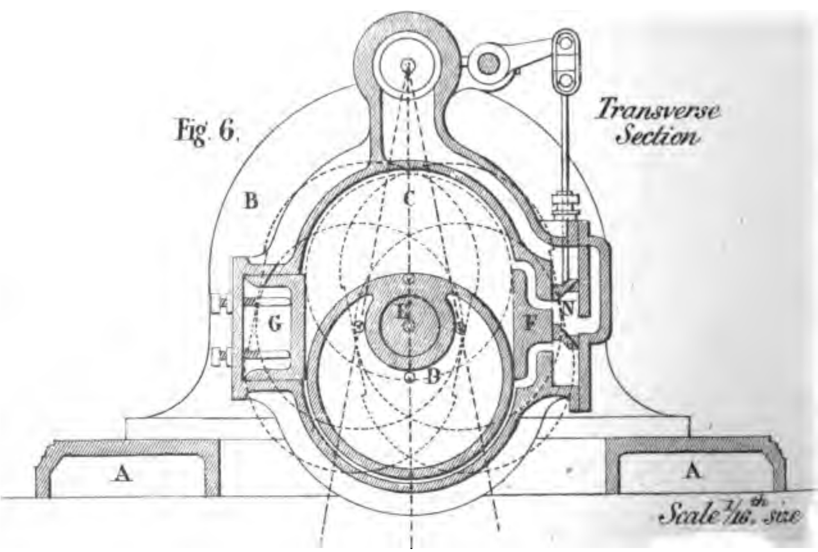


Fig. 6.

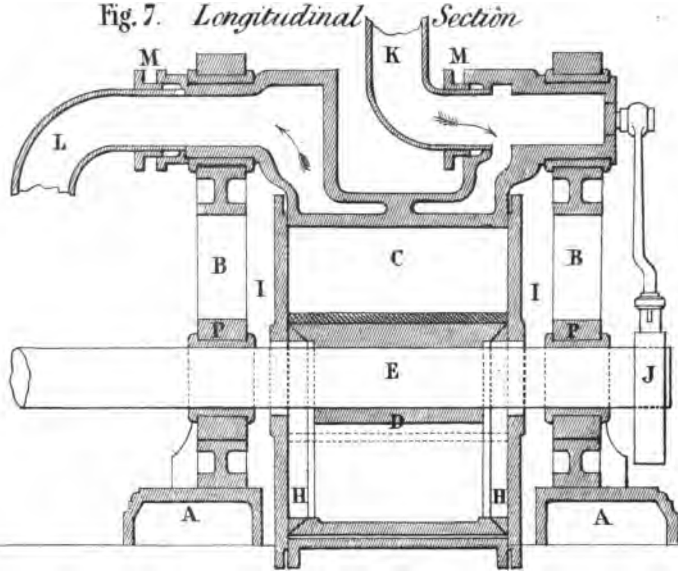
Transverse Section



Scale 1/16th size

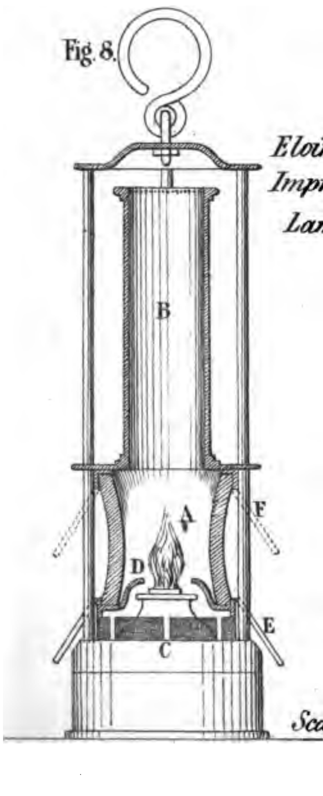
SHIPTON'S PENDULOUS ENGINE.

Fig. 7. *Longitudinal Section*



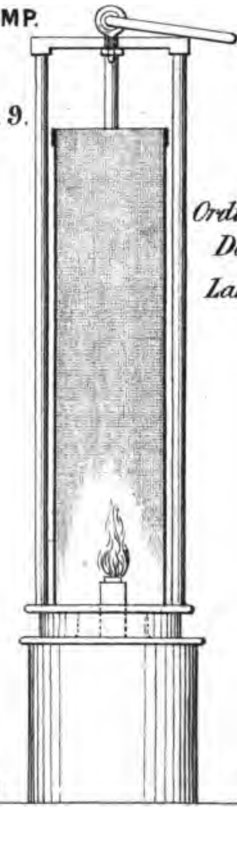
MINER'S SAFETY LAMP.

Fig. 8.



Eloin's Improved Lamp

Fig. 9.



Ordinary Davy Lamp

Scale 1/3rd. size

Plate 44.

CREOSOTING TIMBER.

Fig 1 *Transverse Section of Pressure Tank.*

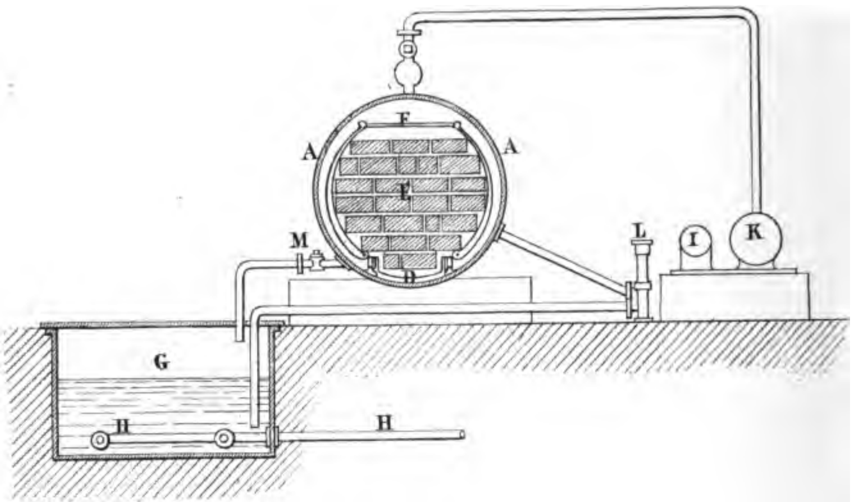
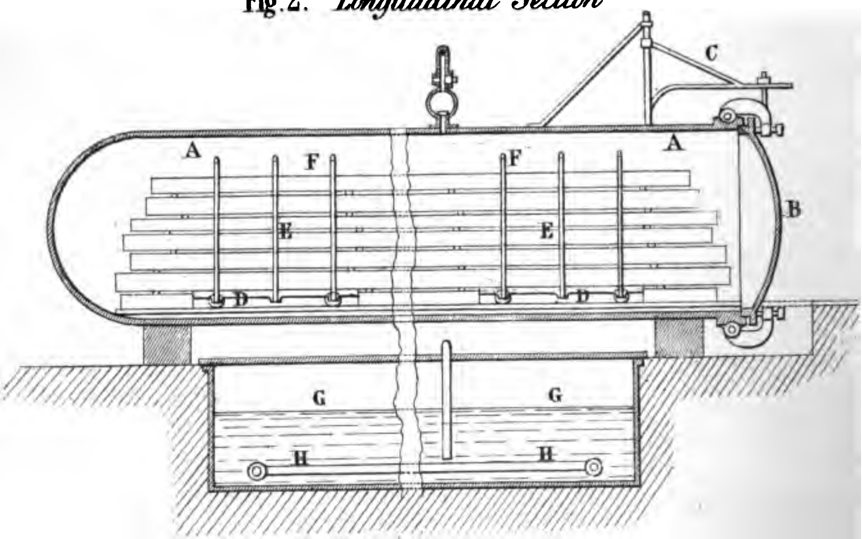


Fig. 2. *Longitudinal Section*



Scale 1/70th size

CREOSOTING TIMBER.

Fig. 3. *Transverse Section of Drying House*

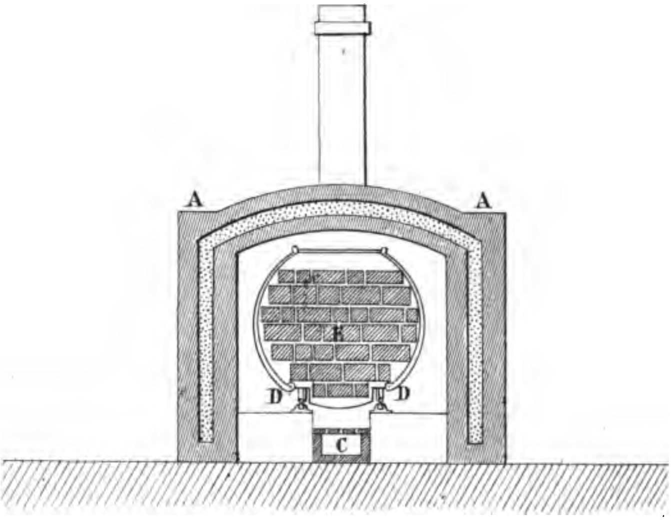
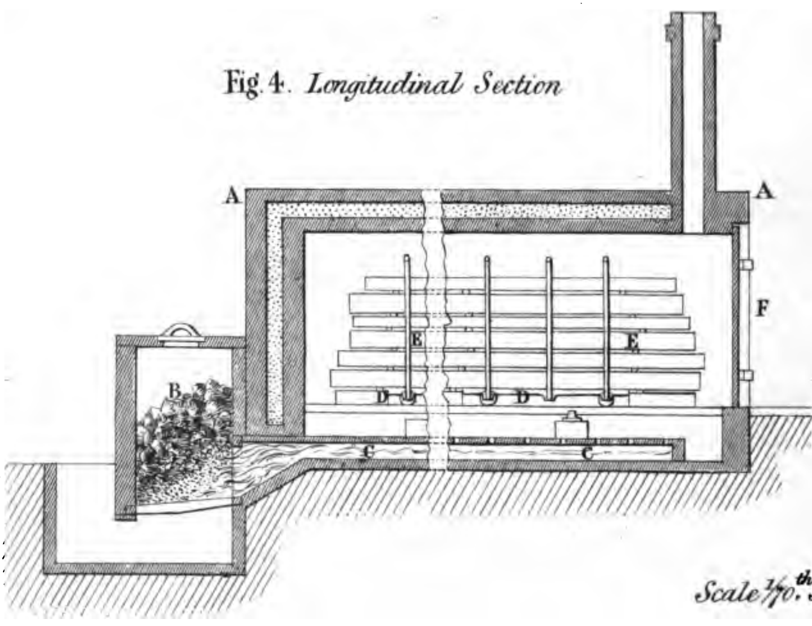


Fig. 4. *Longitudinal Section*

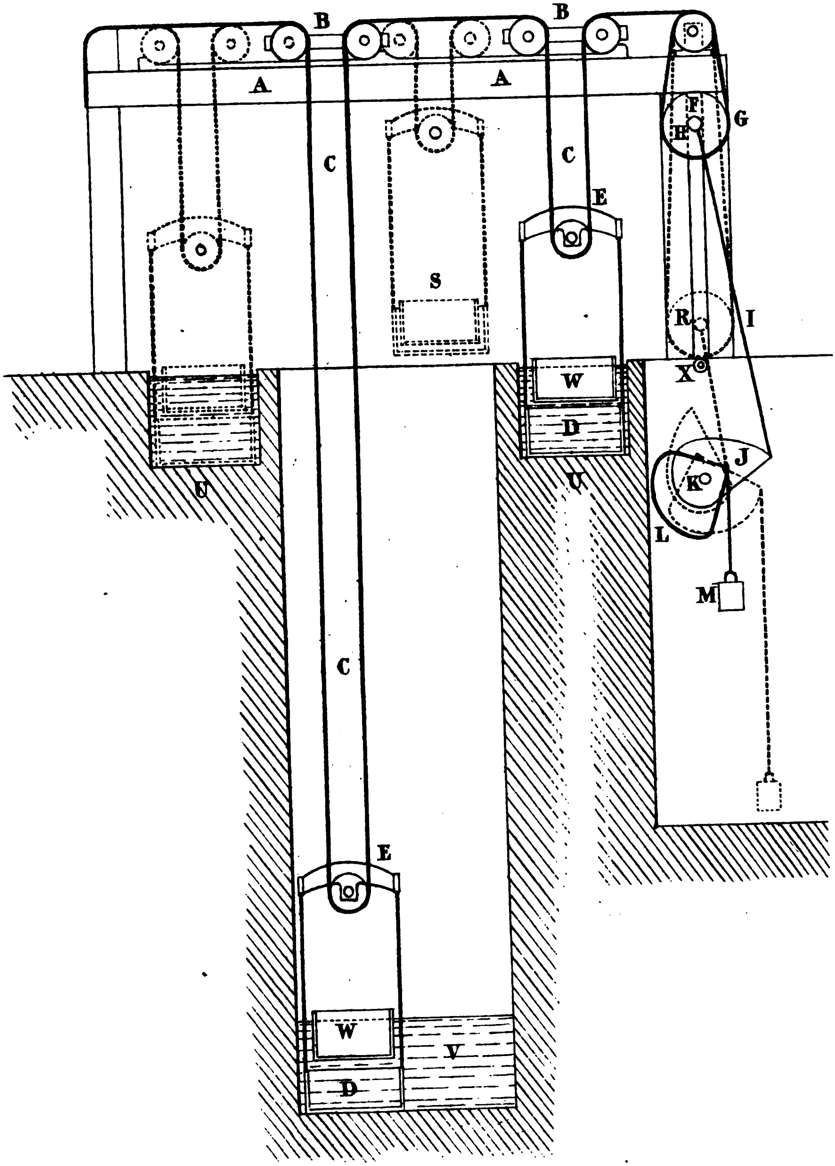


Scale 1/70th size

Plate 46

CANAL LIFT.

Transverse Section

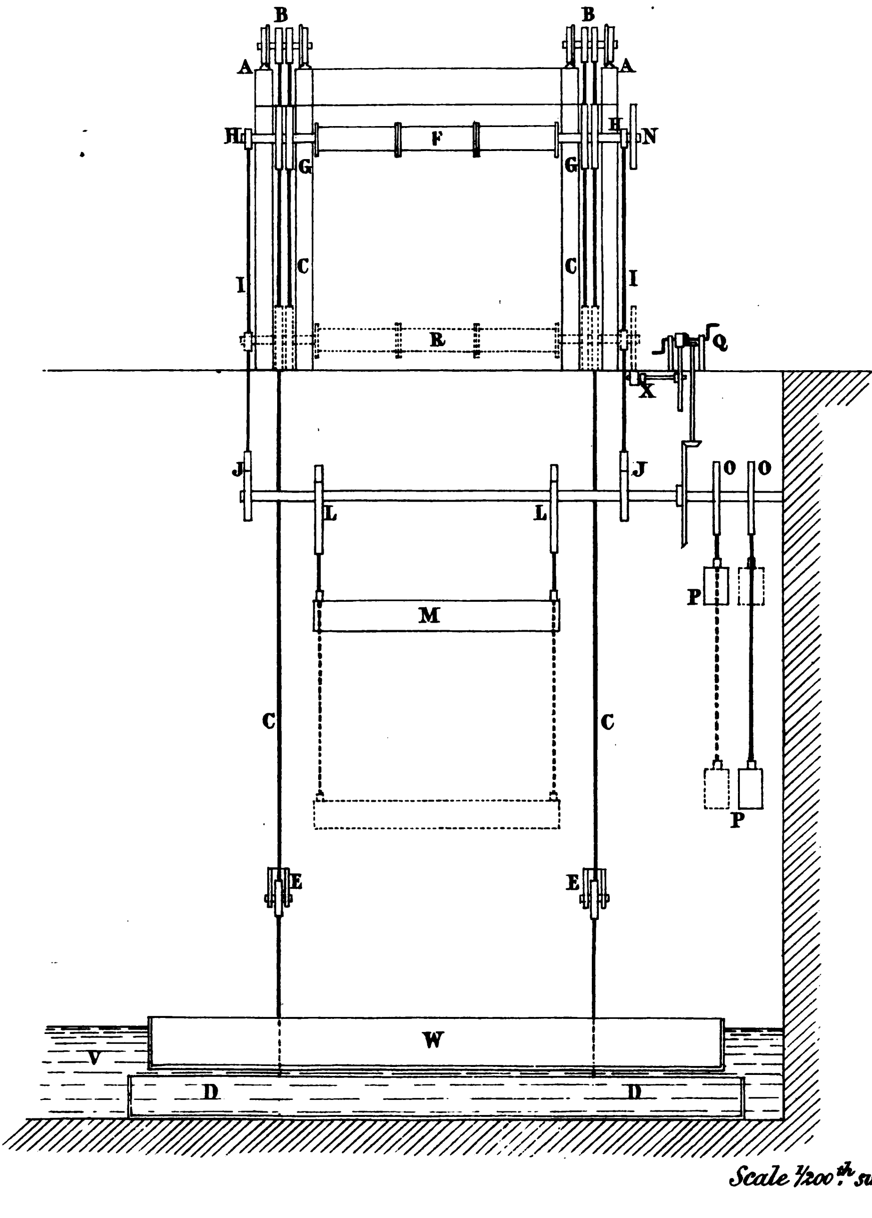


Scale 1/200th size

Plate 47

CANAL LIFT.

Longitudinal Section.



Scale 1/200th size